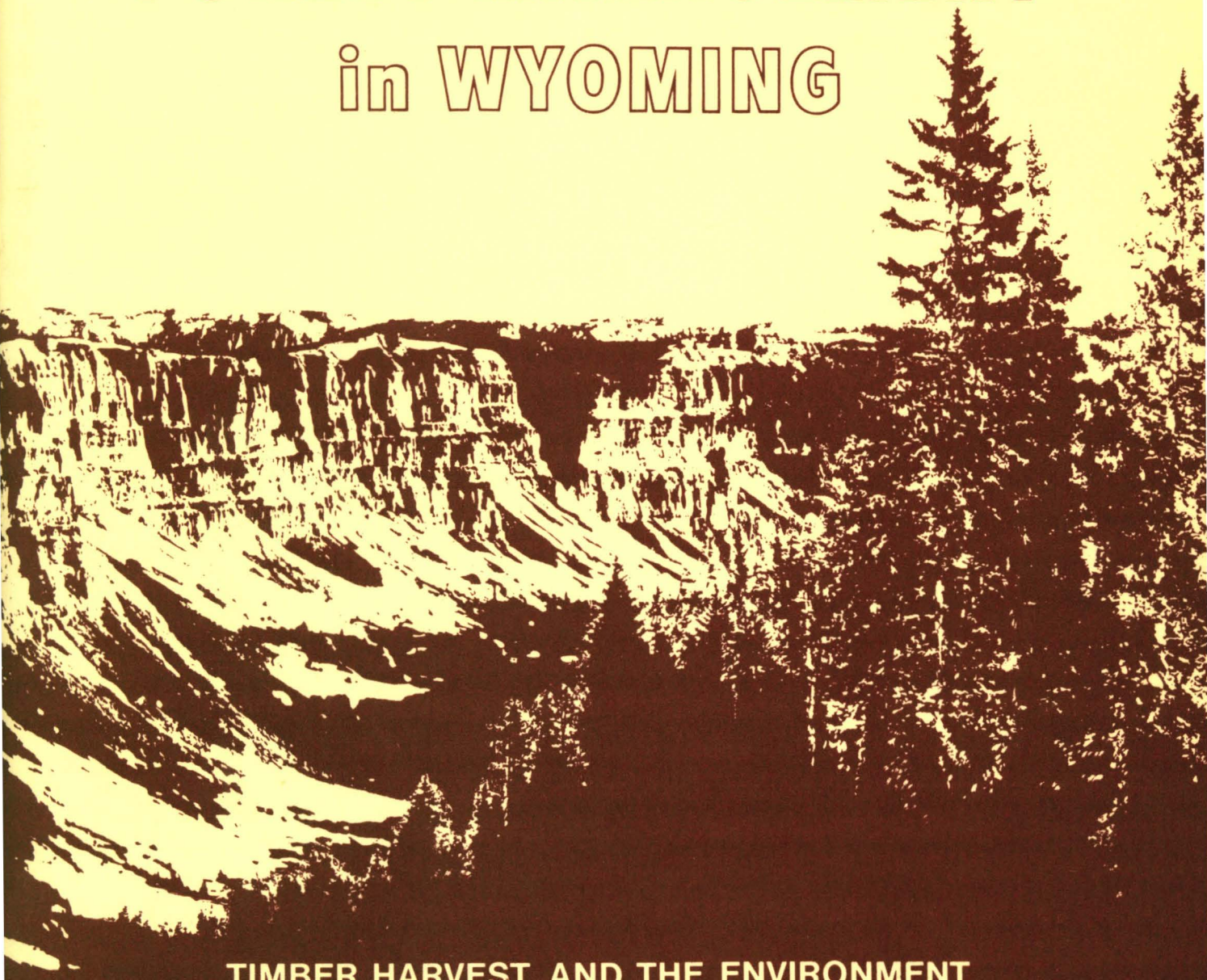
SD144
W8W8
pt. 1
c. 1

2400 - TIMBER
#5 (KEEP)

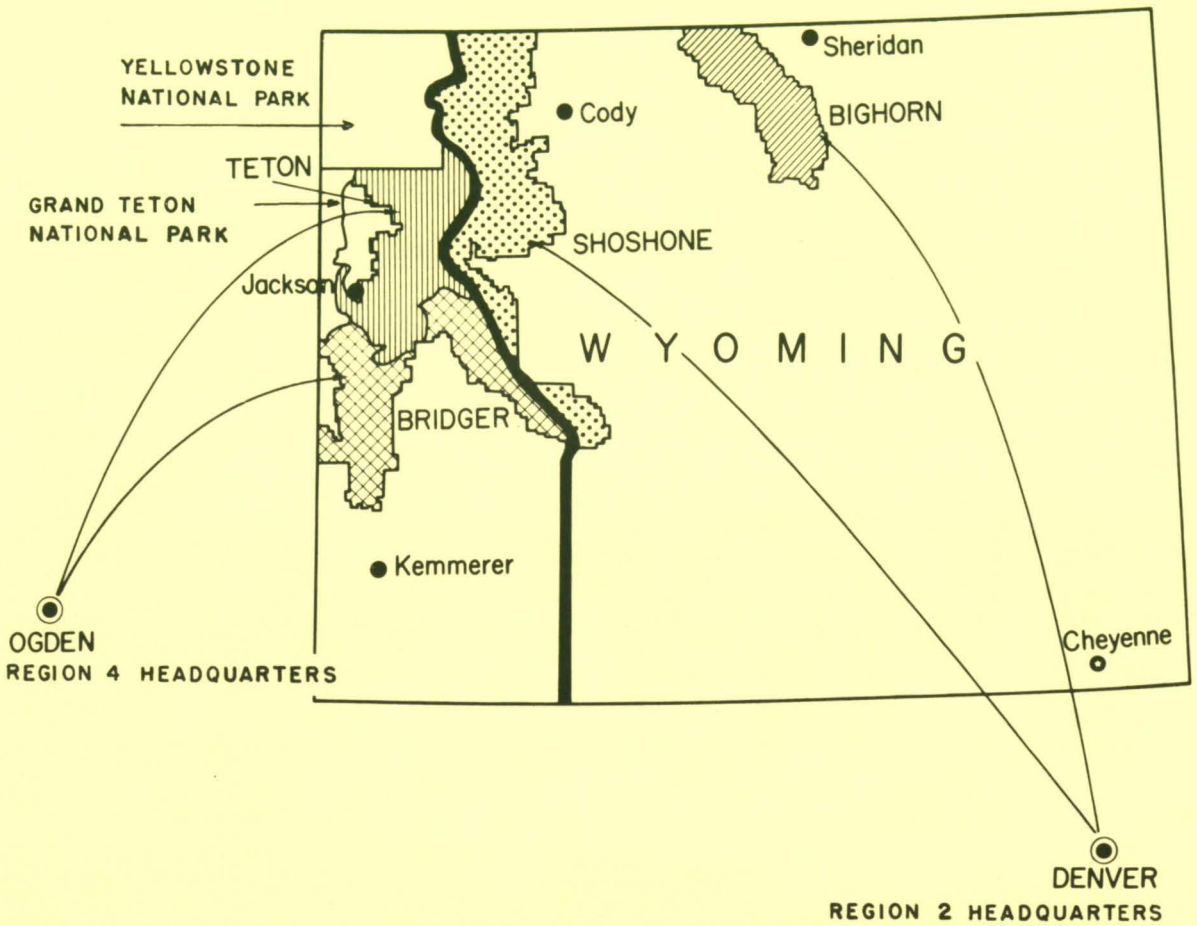
FOREST MANAGEMENT in WYOMING



TIMBER HARVEST AND THE ENVIRONMENT ON THE TETON, BRIDGER, SHOSHONE, & BIGHORN NATIONAL FORESTS

WYOMING FOREST STUDY TEAM
FOREST SERVICE : U. S. DEPARTMENT OF AGRICULTURE

1971



The four National Forests of northwestern Wyoming have a combined area of approximately 7 million acres, including more than 2 million acres in Wilderness and Primitive Areas.

Portions of the present Forests were set aside as Forest Reserves in the 1890's. Through a complex series of changes in name and area they have evolved into the present administrative units. Their colorful history recalls Indian battles and cattle wars, the early fur trade, and the Oregon Trail.

The waters of northwestern Wyoming flow to the Columbia, the Missouri, and the Colorado River systems, and the mountain peaks include 13,785-foot Gannett Peak, the highest point in Wyoming.

The Teton National Forest covers 1,687,932 acres and includes the 563,500-acre Teton Wilderness.

The Bridger National Forest covers 1,711,719 acres including 383,300 acres in the Bridger Wilderness.

The Shoshone National Forest covers 2,431,949 acres and includes 834,234 acres in the North and South Absaroka Wilderness and 450,930 acres in the Glacier, Popo Agie, and Stratified Primitive Areas.

The Bighorn National Forest covers 1,107,333 acres and includes the 137,000-acre Cloud Peak Primitive Area.

Photographs

Cover: Breccia Cliffs, Shoshone N.F.
Part I: Enos Creek Road, Shoshone N.F.
Part II: Deadman's Creek, Bridger N.F.
Part III: Sheep Creek Overlook, Bridger N.F.

FOREST MANAGEMENT in WYOMING

Timber Harvest and the Environment
on the
Teton, Bridger, Shoshone, and Bighorn National Forests

Wyoming Forest Study Team
1971
U. S. Department of Agriculture
Forest Service

Wyoming Forest Study Team

Carl M. Berntsen. *Chairman.* Assistant Director, Timber Management, Forest Disease, and Forest Insect Research, Rocky Mountain Forest and Range Experiment Station, Fort Collins, Colorado

R. Burton Litton, Jr. Landscape Architect, Pacific Southwest Forest and Range Experiment Station; Professor of Landscape Architecture, University of California, Berkeley, California

L. Jack Lyon. Wildlife Research Biologist, Intermountain Forest and Range Experiment Station, Ogden, Utah; stationed at Missoula, Montana

Paul E. Packer. Principal Forest Hydrologist, Intermountain Forest and Range Experiment Station, Ogden, Utah; stationed at Logan, Utah

P. Max Rees. Regional Multiple Use Planner-Coordinator, Intermountain Region, Ogden, Utah

Jack E. Schmautz. Range Conservationist, Division of Range Management, Northern Region, Missoula, Montana

Acknowledgment

We are grateful to the people, too numerous to name here, who participated in the formulation of this report. We greatly appreciate the expert and timely services of members of the staff of the Rocky Mountain and Intermountain Forest Service Regional Offices and the Pacific Southwest, Intermountain, and Rocky Mountain Forest and Range Experiment Stations. We sincerely thank May E. Huddleston for editorial help.

CONTENTS

Page

Introduction 1
Part I People Are Concerned About Forest Values 3
Historical Background 4
The Direction of Current Forest Management 4
The Sources of Management Deficiencies 8
The Future Course of Forest Stewardship 9
Basic Recommendations 10
Part II People Are Concerned About Effects of Timber Harvest 11
Clearcutting 12
The Place of Clearcutting in Wyoming Silviculture 12
Silvicultural Systems 12
The Basis for Silvicultural Prescriptions 13
Management Alternatives for Harvest 14
The Profit Element in Harvest Methods 15
Modifying Clearcutting Methods to Protect the Environment 16
Choosing Timber Harvest Areas 16
Determining Size of Clearcuts 16
Protecting Watersheds and Fisheries 17
Protecting Wildlife 21

Protecting Recreational Opportunities . . . 23
Protecting Scenic Quality . . . 26
Roads . . . 39
Road Planning and Maintenance . . . 39
Density Level . . . 39
Suitability of Roads . . . 40
Closure of Temporary Roads . . . 42
Controlling Environmental Effects of Roads . . . 43
Watershed . . . 43
Wildlife . . . 48
Landscape Quality . . . 50
Logging Residue . . . 55
Residue Treatment on the Forests . . . 57
Controlling Environmental Effects of Residue . . . 58
Air and Water Quality . . . 58
Soil Stability . . . 59
Wildlife Habitat . . . 60
Scenic Quality . . . 60
Regeneration . . . 62
Regeneration in Lodgepole Pine . . . 62
Seed Production and Dispersal . . . 62
Seedbed Requirements . . . 62
Regeneration in Spruce-Fir . . . 62
Regeneration Practices on the Forests . . . 63
Natural Regeneration of Lodgepole Pine . . . 63
Artificial Regeneration of Lodgepole Pine . . . 65
Spruce-Fir Regeneration . . . 66
Grazing Damage to Regeneration . . . 66
Logging Residue Treatment and Regeneration . . . 66
Part III People are Concerned About the Quality of Forest Stewardship . . . 68
Making and Applying Management Decisions . . . 69
The Planning Process . . . 69
The Use of Available Information . . . 69
Resource Inventories . . . 69
Scientific and Technical Information . . . 70
Records and Administrative Studies . . . 70
The Search for New Knowledge . . . 70
Staffing and Financing . . . 71
Personnel Tenure and Responsibility . . . 72
Correlating Management Policies . . . 73
Involving People . . . 75
Summary of Recommendations . . . 76
Literature Cited . . . 80

SD144
W8W8
pt.1
c.2

INTRODUCTION

In recent years, forest management practices, notably clearcutting, on four National Forests in Wyoming, have been a focus for controversy. Strong criticism has been heard in letters, news articles, and public statements. The issues are important for the owners of these lands — the American people — and for the Forest Service — the agency assigned to protect and manage them in the public interest.

In response to public concern, the Regional Foresters of Regions 2 and 4, who administer these four Wyoming Forests, appointed a team to analyze the various problems. We, the study team, all scientists or resource managers, are members of the Forest Service, but not directly responsible for on-the-ground management. Our charge was to review timber management practices on the Bighorn and Shoshone National Forests of Region 2, with headquarters in Denver, and on the Teton and Bridger National Forests of Region 4, with headquarters in Ogden. Our instructions were (1) to explore fully the concerns and apprehensions of individuals and organizations in Wyoming, (2) to conduct the study in accordance with section 102 of the National Environmental Policy Act of 1969 (Public Law 91-190, January 1, 1970), and (3) to report our findings candidly — to "tell it like it is" — and recommend any needed changes in management practices.

In making our analysis, we relied on two principal sources of information. One was a combination of field examination, review of pertinent plans and policies, and gathering of statements from employees at Regional, Forest, and Ranger District levels. The other was verbal and written communication with individuals who spoke as representatives of a wide variety of organizations, companies, and local governments, and who also expressed their own strictly personal viewpoints. We also employed Mr. Arthur L. Roe, Consulting Forester and a member of the Forestry School Staff, University of Montana, to make an independent evaluation of silvicultural practices.

We made air and ground observations of timber management practices on all four Forests during July 1970, accompanied by Forest Service personnel. As a group, we spent about 2 hours air time and 2 or 3 days field travel on each Forest; some individual followup visits were also made.

Most of the Forest Service employees we talked to expressed strong attachment to the land and a personal and professional pride in striving toward excellence in stewardship. We encountered no attempt to disguise the existence or magnitude of land management errors. Our discussions and the written statements we received expressing individual points of view provided a broad and relatively unguarded critique of Forest Service management practices. Many of the criticisms in this report and the suggestions for needed changes came from Forest employees.

These first contacts with people — Forest Service people — gave us considerable insight into the depth of concern by individuals. Even so, we were not quite prepared for what developed during the next 2 months as we followed through in our contacts with people outside the Forest Service.

Our visits developed in a free and unstructured style. Outfitters, guides, doctors, law-

yers, businessmen, politicians, home builders, artists, dude ranchers, government officials, retirees, newsmen, loggers, hunters, foresters, and a generous assortment of others gave their time and attention, and often their hospitality, to a study team with a seemingly impossible task. Opinions, facts, recommendations, and condemnations flowed from individuals and groups in great variety — motivated by a variety of concerns, emotions, and prejudices, including the prevailing mood of the nation to exercise the right to question. If all this could be put to music, there might be a horrendous discord, except for one common chord — the resolve to assure proper management of forest land resources.

This land of Wyoming is home to a hardy stock. Residents seemingly thrive on bucking the elements and on the physical exhaustion of back-country exploration. In communities throughout the study area, sometimes hundreds of miles apart, but apparently still welded by the pioneer spirit, people spoke freely and repeatedly of their feeling for the land — "this is my country."

The concerned individuals were not always those of the "old guard." Young men and women — some in the early years of their careers, some just beyond apprenticeship in family enterprises, some still doing college and graduate work — vigorously participated in dialogues with us.

Opinions varied widely, even in groups representing a single organization. Although these opinions were frustrating to analyze, our encounters with people were refreshing. We were impressed by the independence we recognized in so many individuals.

This grassroots approach to problem examination gave us a sense of personal involvement. Corresponding with interested persons was the springboard to our learning the magnitude and depth of concerns. The written statements we received were accompanied by requests for person-to-person discussions. We visited with a kindly gentleman in a church, with a smartly dressed lady in a dingy hotel meeting room, with a mayor in the town hall, with a convalescent in a hospital solarium. We talked with dude ranchers out on the ranch, with conservation groups at "downtown" meetings, with timber industry men in the woods or at the plant site, with homeowners at their summer home sites, and with both appointed and elected officials at their offices or wherever we found them. Occasionally, these concerned people took us to see examples of the timber harvesting activities that had aroused their concern.

Not all the opinions expressed were in opposition to Forest Service timber management practices. Some fully supported past and recent management actions and current plans. Not all opposition protested the same forest management activities — some opposed clearcutting and roadbuilding, some opposed roadbuilding but not clearcutting, and some recommended intensive timber production on designated areas only. And not all expressions of discontent were related to Wyoming timber management — other National Forests, summer home permits, grazing management, recreation facilities, and wilderness management all came in for some comment. This wide range of interests and concerns we saw as part of an overriding issue — the people want the Forest Service to be sensitive to their needs, to their interests, and to their desire to participate in decisionmaking.

The views we heard were essential in giving us the necessary perspective on timber management practices on the four Forests. The impressions and testimony we gathered are synthesized to the best of our ability in the pages of this report. We recognize that the Forests have a wealth of resources important to people in Wyoming and elsewhere, in both consumptive and nonconsumptive values. There is little doubt that we have not explored all the ramifications of the problem of using these resources wisely. Knowledge and understanding of social, cultural, economic, and environmental forces are basic to achieving long-term multiple use benefits. Admittedly there are limits to our capabilities. We have not undertaken to evaluate the broad social and economic aspects of the National Forest System programs in Wyoming. We hope, nevertheless, to have clarified, within the scope of our combined competence, some specific problems of management. Thus we have taken a few steps toward the vital communication that is so necessary between a public agency and the people it serves.

PART I

People Are Concerned About Forest Values

Our investigation of forest management in Wyoming confirms that a confrontation has developed between residents of the State and the Federal agency charged with protecting the public interest in National Forest lands. In essence, the criticism we heard is that the Forest Service has given priority to timber production, whereas it should have given priority to watershed, wildlife, recreation, and scenic values; that is, to preserving the quality of the environment. This criticism is implicit in a variety of specific protests against Forest Service activities, such as clearcutting, road construction, handling of logging residues, and efforts at regeneration of harvested areas. Public confidence in the ability of the Forest Service to manage the Forests has suffered. The Service is accused of lack of knowledge, lack of understanding, and lack of response to the wishes of the people of Wyoming and of the Nation.

These accusations pose important questions: Has there been or is there likely to be permanent or avoidable temporary damage to a resource? Can the Forest Service involve people by informing them and using their abilities and thus increase public confidence? The solutions for these problems are not simple and cannot be stated briefly. An overview of the problems and certain broad recommendations are presented now, however, as a foundation for the discussions and more specific recommendations in Parts II and III.

Historical Background

Dissatisfaction with Forest management in Wyoming is of recent origin. Until the late 1950's and early 1960's there was little timber management in the State. Forest Service management, beginning in the early 1900's, started with a fire protection program. Until the 1950's, timber cutting was chiefly for railroad crossties, sporadically harvested from many of the more accessible stands of lodgepole pine (the local term is "tie-hacking"). Small volumes of timber were also cut for lumber, posts, and poles. These were mostly "highgrading" operations using horses and small machines and removing only the bigger and better trees. Also, starting in the 1930's and continuing until the mid-1960's, insect control programs were carried out. Generally these were regarded as holding actions: their purpose — to protect timber values until market demands would permit harvesting and subsequent establishment of new stands of trees. These activities apparently had general public support; at least, they did not provoke criticism from noncommercial user groups.

By the late 1950's, new developments in harvesting and milling technology, together with increased demands for lumber supplies, altered the economic picture for lodgepole pine timber from these Forests. National Forest managers saw the opportunity to convert old deteriorating forests to young vigorous ones. Conversion would prevent further losses to insects and disease and at the same time contribute to the public welfare by creating new jobs and by helping to supply lumber needed for accelerated housing construction. Most people welcomed the changed social and economic outlook as an improvement. On this positive basis, the lumber industry, encouraged by the Forest Service, quickly built timber processing plants at key locations adjacent to these National Forests. Shortly thereafter, hundreds of acres of lodgepole pine and some spruce forests were being clearcut in large units, mills were operating at full capacity, and plans were being made to expand timber harvesting to the sustained-yield levels indicated by timber inventory information.

By about 1965, the apparently unforeseen visual impacts of clearcut timber harvesting reached the public. The result was organized opposition. The belief became widespread that continued harvesting of timber in the high-altitude forests of Wyoming would have serious adverse effects on soil, water, fish and wildlife, and landscape values. This belief took on special currency with the rapidly increasing public attention to environmental quality during the late 1960's.

Northern Wyoming is singularly blessed with magnificent landscapes and rich resources of water and wildlife; many residents consider these the essentials of a quality environment. For some, even minor change is degradation, and timber harvest produces more than minor changes.

In the view of many people in Wyoming, timber harvesting as practiced on the four Forests represents overemphasis on timber production goals at the expense of other resource values. We were told repeatedly that the wildlife and scenic resources of northern Wyoming are nationally significant, whereas the timber resource is only locally important.

The Direction of Current Forest Management

Much of the criticism we heard was directed to specific logging practices. Nevertheless, it was evident that even if timber harvesting were done in the best possible way there would still be some public opposition to any timber harvest on these four Wyoming Forests. Opinions were confusingly contradictory. We were told that Forest Service timber sale programs respond to industry demands and mill capacities without regard to sustained yield, and conversely, that vast tracts of valuable timber are being wasted in locations where the Forest Service has restricted harvest to avoid conflicts with other resource uses. We heard that continuation of present cutting would cause a loss of tax base and jobs when the timber was gone.

Figure 1. — The clearcut here is unduly large, and adverse visual effects on the stream zone are apparent. (Sheridan Creek, Shoshone National Forest)

Then we heard that any cutback in sales volume would be a waste of valuable resources and cause reduced tax base and jobs. We were told that the Organic Act of 1897 and the Multiple Use Sustained Yield Act of 1960[1] require the Forest Service to authorize timber harvest on Forest lands; we heard also that timber harvest in Wyoming is economically unsound regardless of its effect on other resource values. Attitudes crystallized into three main positions: (1) that Wyoming timber is already overharvested, (2) that overreaction to criticism is causing underharvest, with serious economic effects and (3) that there should be no timber harvest in the Wyoming National Forests.

We believe that public concern about overharvest is an understandable reaction to visible evidence on the ground. The appearance of overharvest in many places is created by timber management practices that were uncoordinated or in conflict with the protection of other resource values, as we will illustrate in later sections of this report. We found much evidence of good management, but we also found indications of serious shortcomings. There was some evident damage to wildlife habitat and to soil stability. More frequently, a potential for such damage was clear, although no evidence of damage could be found. Damage to the scenic quality of the landscape, however, was unmistakable.

Four examples, one on each of the four Forests (figs. 1-4), are representative of what we found. The conflict between timber and other values is evident. These operations, carried out some years ago, have been roundly criticized, not only by the public but also by members of

[1] *The Multiple Use — Sustained Yield Act of 1960 (16 U.S.C. 528-531) provides that decisions be made "... with consideration being given to the relative values of the various resources, and not necessarily the combination of uses that will give the greatest dollar return or the greatest unit output." (Section 4(a)). It defines sustained yield as "... the achievement and maintenance in perpetuity of a high-level annual or regular periodic output of the various renewable resources of the national forests without impairment of the productivity of the land." (Section 4(b)).*

Figure 2. — The quality of a wilderness entry has been degraded by insect control cutting. (Jim Creek, Bridger National Forest)

Figure 3. — Logging here has left unsightly residue and has removed cover around a pond. (Union Pass, Fish Creek, Teton National Forest)

Figure 4. — The cutover area dominates this view of the landscape from a highway. (Owens Creek, Bighorn National Forest)

the timber industry and the Forest Service. Careless harvesting and incomplete rehabilitation have created the impression that only timber values were considered. We believe that there have been inadequacies in planning, in execution, and in evaluation of management actions on all four of the Wyoming Forests, and that the evidence justifies concern for the future. The results of present actions will not be clear for some years, and it is important that past errors should not be repeated.

The possibility of overreaction leading to underharvest is hard to evaluate. Undoubtedly, current multiple use planning is more comprehensive than past planning has been. As it brings greater concern for quality in land management, it will also make future timber sales more expensive. Whether added costs will bring about a reduction in the amount of wood harvested is not yet clear.

Finally, we believe that prohibition of timber harvest, although worthy of consideration, is neither necessary nor desirable. Each of the Forests has allowed logging in areas that would have been better left uncut; each has allowed some cutting with apparent disregard for other values and other resources; and each has experienced some regeneration failure. Nevertheless, each Forest has areas of timber production potential where management for wood production is proper. Moreover, even where the timber production potential is low, cutting can be a useful land management option. Timber harvesting cannot be done invisibly, but it need not be a desecration. Generally, harvesting can be done without impairing other values if management practices are appropriate. It can enhance other values. Timber harvest, including clearcutting, can be successfully used to improve wildlife habitat and water yield. Forests can be managed for environmental quality as well as for wood products.

The Sources of Management Deficiencies

When citizens criticize the actions of public agencies, there is always a tendency to blame the administrators. Seldom, however, is this simplistic approach justified. We have no wish to gloss over or excuse management errors. Nevertheless, we must point out that many of these resulted from conditions outside the control of the Regional Foresters and personnel of the individual Forests, or from policies believed to be in accord with public opinion at the time. Lack of information from research and lack of manpower for fact gathering and sale administration on the Forests were also contributing factors.

A primary target of protest, the apparent overharvest of timber, was partly a response to Federal law and USDA regulations that the Forest Service harvest timber to satisfy an obvious public need. It is apparent now that the estimates of allowable cut were partly based on over-optimistic assumptions as to the amount of growth on forested lands that was suitable, available, and economically feasible to harvest. Since much of the forested land in certain parts of Wyoming is unloggable under present technology, the cut was concentrated in the area that could be logged.

Concurrently, the use of timber cutting as a means of control of bark beetle infestation led to logging where no logging should have been done. The experience of the past 10 years has demonstrated that this logging was largely a vain effort but at one time it appeared to be a logical extension of Forest Service policies aimed at forest protection.

The frequent failure to apply the principles of landscape design in layout of cuttings is criticized in this report. Only a few training opportunities in landscape architecture related to forestry programs are now available, however. Although the Forest Service employs more landscape architects than any other Federal agency, none of these four Forests have them. The Forests cannot make completely effective use of the landscape architects in the Regional Offices because of distance and scheduling difficulties.

The most apparent cause of the management weaknesses we observed was the lack of adequate multiple use planning. Commonly this deficiency stemmed from the lack of basic inventory information about the land and about people's needs. Good multiple use plans can be prepared only when sound resource and ecological data, and reliable information about social, economic, and environmental values and needs are available. Counsel from the public and interested organizations is an essential part of this information. Only on this basis can management objectives be properly established and coordinating decisions made in each facet of the management program.

Inadequate planning has sometimes been accompanied by inattention to existing guidelines for execution of management programs. Guidelines have been neglected in such matters as closure of temporary roads, treatment of logging residue, and efforts at insuring regeneration in cutover areas. We found frequently that problems could have been avoided had the man on the ground simply done "what ought to be done."

A search for the deeper cause of this kind of neglect brings us to the problem of staffing and financing. "We don't have enough well-trained people or enough money to do a quality job of timber management" was, in essence, the message we heard from on-the-ground Forest Service people. The basis for this contention was convincingly demonstrated. Jobload calculations on time requirements and judgments of level of competency needed to perform quality work have missed the mark. We learned that employees with inadequate training and experience in silviculture and multiple use coordination were making the field decisions on sale layouts and harvesting practices because Forest Service officers who have the proper background are burdened with too many other essential duties to give detailed attention to this work. In sale administration, we were told, and our observation confirmed, that competent people were overburdened with work, or inadequately prepared employees were doing this important job. Finally, we found that none of the Forests had an employee trained in landscape architecture, and that all were short

handed in such important disciplines as wildlife biology, soils, and hydrology.

The staffing problem and the associated problem of frequent transfer of personnel on the Forests have led to another important weakness in management. Evaluation of past actions has been insufficient to detect errors, correct them promptly, and avoid their repetition. A man who has his hands full with future assignments is not likely to look closely at past actions. It is clear, however, that there has been a general failure to provide for the necessary time to look at what has been done and at the results after some years have passed. Especially in the area of regeneration was this deficiency noticeable: evaluation of past failures with natural regeneration would have led to planting in many areas that are still bare, and similar evaluations of plantings would also have been helpful.

Among the probable causes of management deficiencies we must also include timber sale policies and contract requirements that have led to harvest without adequate provision for land restoration and regeneration. We have made no specific evaluation of these except as they relate to forest practices discussed later in the report. It is clear, however, that land restoration and regeneration costs were sometimes not covered by the value of the timber sold.

The Future Course of Forest Stewardship

Obviously, some uncertainty exists in the public mind as to the future of the Forests. We must say, however, that to a large extent, management weaknesses are already recognized by the Forest Service and measures are being taken to correct them. This report evaluates these actions and suggests ways in which they should be speeded up and reinforced.

The two Regional Foresters have provided Multiple Use Management Guides. Within these frameworks, each of the four Forests has progressed in multiple use planning during the past decade. But, the rate of progress varies and no Forest has attained the refinement needed to assure that all values and needs are adequately reflected and properly blended.

The Forests are obviously responding to the need for improvement. But the lack of adequate staffing is a stumbling block in their efforts to accomplish the complex job of planning while carrying out current administrative and protective duties. We concluded that there is urgent necessity to refine, revise, and update existing multiple use plans. The effort to do this within the present organization and staffing framework cannot succeed without additional financing or some reduction in existing programs. Time and capability to evaluate and analyze forest management alternatives are simply not available.

The Forest Service must strive to increase public confidence and trust. This will not be achieved by rhetoric, but will require repeated demonstration that declarations for quality in management are actually appearing as physical accomplishment on the ground. Results of effective multiple use planning are beginning to show on the land in some places. The Forest Service should not expect, however, that confidence and trust will be strengthened quickly. Neither should the public expect that new management direction will appear instantly and completely in all activities. It is imperative, however, that open communication be maintained between the Forest Service and the public and that statements and actions of every Forest Service employee meet the highest standards of professional competence.

Basic Recommendations

As a result of our investigations, we present the following broad recommendations for future action. In later sections, more specific recommendations are found following discussion of management practices.

- The importance of wildlife, recreation, and scenic quality as key values should be recognized in every management decision on the National Forests of Wyoming.

- Multiple use planning should be a team effort, using input from Forest Service specialists in all appropriate areas of knowledge, and from interested citizens and organizations as well. Therefore:

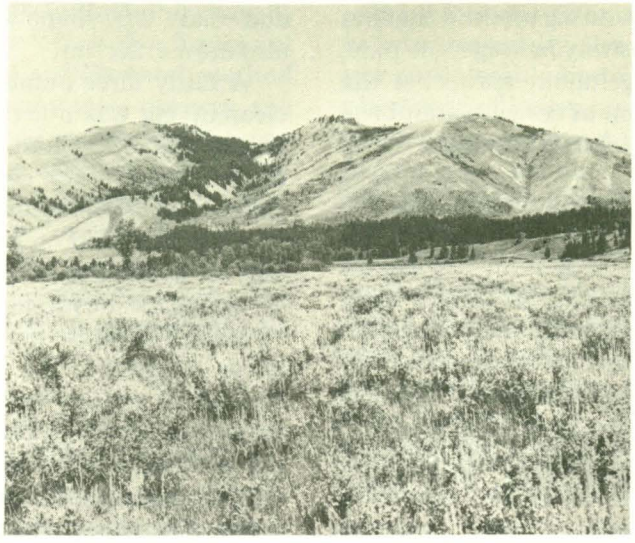
    - Plans reflecting these inputs should be clearly stated and announced to the public in an understandable form.

    - Agreed-upon plans should be fully implemented in a manner clearly evident to the public.

    - The effectiveness of planning should be periodically evaluated and the results reported to the public.

- Needs for adequate staffing for the development, implementation, and evaluation of plans should be explicitly stated in Forest Service budget requests.

- Every member of the Forest Service should be committed to the principles of high-quality multiple use management and to the urgent necessity for putting these principles into practice.



PART II

People Are Concerned About the Effects of Timber Harvest

In Part I, we have outlined the primary concerns of this report. In Part II we explore the problems more fully and specifically. Clearcutting requires road construction, produces logging residue, and must be followed by regeneration. Although they are closely linked, the particular problems associated with these practices are conveniently discussed separately.

Our aim in this discussion is not to place blame for the mistakes of the past but to learn from them. This report would have little value, however, if specific illustrations were not given. Many of the examples cited here are negative, because these make their point most clearly and dramatically. Yet it would be inaccurate and an injustice to much excellent management on the Forests to report only negative observations. We found harvests that were made carefully and respected the surroundings and forest values other than timber. We found roads well designed and well related to desirable access for generalized use. We found logging areas that showed evidence of high-level cleanup of wood residues. We found cuttings on which regeneration has been good and forest cover is being returned. In short, we found a substantially higher quality of management than the public criticism implies.

Clearcutting

Clearcutting, the harvesting method that has been used almost exclusively in lodgepole pine, and frequently in Engelmann spruce, is the overwhelming focal point of concern about National Forest management in Wyoming.

Almost without exception, critics protested the size of clearcuts. Forest Service personnel agreed that many cuts had been too large, and even the loggers, who would presumably benefit from large cuts, did not advocate the extensive openings created by some of the older timber sales. Another common theme was damage — real, potential, or suspected — that clearcuts might do to watersheds, wildlife habitats, recreational opportunities, and scenic values.

Criticism on purely esthetic grounds was also very common. Much objection was expressed to the devastated appearance of cutting areas, centering particularly on logging debris and roads. The shape and location of clearcuts also drew criticism.

A fairly large number of people stated that clearcutting was not really necessary and suggested that other harvest techniques might be used instead. Very commonly, we heard the concurrent observation that clearcutting can only be defended on economic grounds: it was said to be the only way the low-yield forests of Wyoming can be logged at a profit.

Many Forest Service employees participated in or suggested the criticisms we have described. In various ways, however, they also expressed another concern — that past misuse of the technique might result in the loss of clearcutting as a silvicultural option. Industrial foresters also voiced this concern. Better understanding of the real value of clearcutting is needed. At the same time, understanding of the proper use of this method is also needed to avoid undesirable consequences.

The Place of Clearcutting in Wyoming Silviculture

Clearcutting is only one of the alternative harvest methods open to the forest manager. The choice among alternatives is dictated by many conditions.

SILVICULTURAL SYSTEMS

Over several centuries, foresters have developed two major silvicultural systems, even-aged and uneven-aged. Though devised mainly for timber production, these systems are based on the ecology of forest tree species. Hence they are also adaptable to other forest uses.

In the uneven-aged, or selection system, trees are harvested singly or in small groups throughout the forest on a regular schedule determined by growth rate. This system creates a forest that consists of all sizes of trees, from seedlings in new openings to fully mature trees ready for harvest. It simulates the process of death and replacement of trees in a forest free of major natural disturbances that interrupt successional stages of forest ecosystems.

Even-aged silviculture simulates the process of death and replacement after natural disturbances — fire, windthrow, or outbreaks of destructive pests. All trees on portions of the area, rather than individual scattered trees, are harvested on a schedule that permits the process to go on indefinitely. The basic idea is this — if 100 years are required for a tree to grow to a desired size, 1/100 of the forest acreage is harvested annually. Even-aged silviculture is not as simple in practice as it sounds. Variations in soil productivity and species composition affect growth rates and harvest schedules.

In both systems of management, prompt regeneration is critical. Slowness or failure of regeneration affects many values — production of timber, water yields, recreational opportunities, and scenic quality. In an uneven-aged system, a seed source is available from remaining trees, but regeneration must be left largely to chance because it is difficult or not feasible to prepare a favorable seedbed in the many small openings created by harvest cutting.

In even-aged systems, three basic methods of harvest cutting provide seed in different ways. In the **seed-tree method,** a few selected,

high-quality trees are left in small groups or individually scattered over the harvested area. When the new stand is established, they may be removed or they may be left until a future cut in the new stand. The **shelterwood method** leaves several times as many trees per acre, and these are usually removed as soon as the new crop is established. The **clearcut method** removes all trees in patches or strips. Seed is provided by the surrounding forest walls or cone-bearing slash. The cutting pattern for each method permits seedbed preparation and other treatments to facilitate regeneration of the new stand.

THE BASIS FOR SILVICULTURAL PRESCRIPTIONS

An appropriate silvicultural system for any forest must satisfy management objectives for the land unit, must meet the ecological requirements of the tree species, and must recognize the condition of the forest stand and site. The ecological requirements of tree species differ, and a variety of stand and site conditions and management objectives call for different silvicultural prescriptions.

In Wyoming, lodgepole pine is the major commercial tree species. Engelmann spruce and subalpine fir are less important commercially, but they grow on much Wyoming forest land. Douglas-fir, aspen, and limber pine, though not commercially important here, must be considered in environmental management. Thus, the silvicultural prescription is normally determined chiefly by the ecology of lodgepole pine, Engelmann spruce, or subalpine fir.

Lodgepole Pine

Lodgepole pine grows in a wide range of environmental conditions. In northwest Wyoming it is an important tree in at least five recognized habitat types: (1) subalpine fir — Engelmann spruce/dwarf huckleberry; (2) subalpine fir/pachistima; (3) subalpine fir/pyrola; (4) Douglas-fir/pinegrass; and (5) Douglas-fir/snowberry. In all five of these types, lodgepole pine is a seral or subclimax species: that is, it is strongly intolerant of shade and dependent on such disturbances as wildfire or blowdown for the successful establishment of a new stand. If wildfire or blowdown do not occur for a long time — 300 years or more — it is replaced by subalpine fir or spruce in the first three types, and by Douglas-fir in the last two. Attacks by insects, especially the mountain pine beetle, can considerably hasten the succession and replacement of lodgepole pine — especially in the subalpine fir/pachistima and Douglas-fir/pinegrass habitats. Lodgepole pine stands are also commonly infected by dwarf mistletoe, a small parasitic plant whose sticky seeds spread the infection at about a foot a year, from tree to tree. It seldom completely kills a lodgepole pine stand, but it does cause severe reductions in growth rate, occasionally leading to death of individual trees.

To a degree depending on the past history of the stand with respect to fire and insect effects, lodgepole pine shows the genetic trait of cone serotiny — that is, cones may remain closed and in place on the tree for many years. Although the theory has not been fully verified, serotiny is generally assumed to be a hereditary trait that is passed on to the next generation when fire kills a stand of lodgepole pine and at the same time opens that segment of a cone crop that is normally closed. Cones of the succeeding stand are predominantly serotinous. In contrast, lodgepole pine stands with a history of insect and disease attacks are often predominantly nonserotinous. Regeneration in the openings in these stands came from the open-cone segment of annual cone crops — the absence of fire precluded or limited dispersal of seed from serotinous cones. Cone serotiny strongly influences the seed source for regeneration and, thus, the appropriate silvicultural prescription for harvest.

Lodgepole pine forests of Wyoming range from sound and thrifty young stands established after recent fires to stands over 300 years old, riddled by disease and insects. Most of these old stands are being replaced naturally by subalpine fir and Engelmann spruce. Where the forest management objective is to grow lodgepole pine rather than spruce or subalpine fir, the silvicultural prescription is to convert mature and overmature lodgepole pine stands to young and thrifty ones.

Clearcutting, well done, is one of the best means to achieve this end because it simulates the natural disturbances that create conditions

favorable for lodgepole pine establishment. It is not, however, the only harvesting method that can be used in even-aged silviculture of lodgepole pine. Even-aged stands can be developed from shelterwood and seed-tree methods as well as by clearcutting. Stands not infested with mountain pine beetle and without serious dwarf mistletoe infections are usually suitable for shelterwood or seed-tree silvicultural treatments. We observed stands in each of the four Forests where one or the other of these two methods seemed applicable.

In shelterwood or seed-tree cutting, the potential loss by windthrow of the residual trees is a disadvantage, but both methods help to regenerate the cutover area. Both also, but shelterwood cutting in particular, have a much milder impact on the environment and on scenic values than does clearcutting.

Selection cutting, even in lodgepole pine stands infected with dwarf mistletoe, can be the most practical method where management objectives other than timber production are foremost. Many of the lodgepole stands we visited had been "tie-hacked" as long as 60 years ago. Such stands now consist of an overstory of trees from the original stand plus an understory of trees in several sizes and age classes. The existence of the understory trees is evidence that lodgepole pine will regenerate at some level of partial cutting.

Where stands have a natural shelterwood condition, another alternative is to remove the overstory, doing as little damage as possible to any advanced regeneration (understory trees) present. This method is most commonly used to convert an older stand into one of a younger age class or of a different combination of species. Overstory removal is most applicable to those lodgepole pine stands in which Engelmann spruce and subalpine fir dominate the understory. Removal of the lodgepole pine is the first major step in securing a different combination of species — species that can be managed as either even-aged or uneven-aged stands.

One final alternative, of course, is to do no timber cutting. This could fulfill the management objective for stands in which the forest cover, no matter how damaged by insects or disease, is best left untouched — in Wyoming even dead trees serve the utilitarian purpose of holding the scenery together.

Spruce-fir

Engelmann spruce and subalpine fir dominate a much smaller part of the four Forests than does lodgepole pine. As climax species and in the absence of fire, they replace lodgepole pine wherever it occurs in three habitat types: subalpine fir — Engelmann spruce/dwarf huckleberry, subalpine fir/pachistima, or subalpine fir/pyrola. Both spruce and fir are shade tolerant and can reproduce successfully under their own closed canopy or that of lodgepole pine. In relatively open forests, spruce-fir stands may be made up of a wide range of ages and sizes, from newly germinated seedlings to overmature trees. Engelmann spruce is highly susceptible to spruce bark beetle and to occasional attacks by spruce budworm. Subalpine fir is also susceptible to spruce budworm and is commonly infected with heart rot. Both lack wind firmness.

In Wyoming, Engelmann spruce and subalpine fir occur beneath lodgepole pine and together in both even-aged and all-aged stands, suggesting wide flexibility in selection of harvesting methods. More than three-quarters of the spruce and fir, however, is in overmature sawtimber stands that offer little opportunity for partial cutting because of their advanced age, slow growth, and likelihood of heavy windthrow. Where insects and disease are not important problems, the single-tree or group-selection methods (to develop an uneven-aged stand) are possible. Shelterwood cutting can also be used in favorable situations, but the cut must be light to minimize windthrow.

MANAGEMENT ALTERNATIVES FOR HARVEST

Many National Forest personnel still consider clearcutting the only way to harvest lodgepole pine economically. Recent Regional directives, particularly from Region 4, have instructed Supervisors, Rangers, and timber staffmen to consider alternative methods of harvest. We feel, however, that the confidence and imagination to carry out the instructions have been often lacking.

We believe that a light selection cutting, particularly on the low-yielding timber sites, should be considered a valid management alternative. Such harvest would remove some mature trees, and the method might best be classi-

fied as "pussyfoot logging" because the logger would leave few tracks. We envision no permanent roads, no site preparation for regeneration, and minimal slash disposal. This harvest method would have little or no detrimental impact on the environment. It would help to maintain or improve the vigor of the stand, and it would make available to industry raw material that would otherwise be lost to decay.

On a somewhat larger area of high-yield timberland, we believe the Forests should try some combination of selection cutting and sanitation salvage — the harvest of dead and dying trees. Neither of these methods may be economic individually, but with some imagination they could be included in timber sales calling for small clearcuts. For example, clearcuts of 5 to 10 acres might serve as yarding areas for selective or sanitation and salvage logging in the surrounding area. Although marginal economically, this type of logging makes the stand more vigorous and productive. Periodic thinning throughout the life of a stand will recover most of the wood that otherwise dies or rots (about one-third of total production). This system might offer an opportunity to reduce acreage of new clearcutting until much of the already cutover land develops into thriving young stands of replacement timber.

Until several years ago, forest managers usually practiced clearcutting in spruce-fir types. Their choice was often dictated by insect epidemics. Currently, because of many regeneration failures in the cutover areas, clearcutting of spruce and fir has been deferred in both Regions until satisfactory regeneration practices can be developed. Regeneration difficulties have also encouraged the use of some form of overstory removal where the advanced regeneration is considered adequate to fully stock a new stand. But this type of timber harvest is costly, because spruce-fir stands commonly contain an excessive amount of cull and dead material that contributes to the difficulty of logging and damages the residual understory.

THE PROFIT ELEMENT IN HARVEST METHODS

The economics of timber harvesting is such a complicated field that we can envision no way to discuss it adequately. On a strictly input-output basis, considering only land management costs and stumpage, it is fairly easy to demonstrate that timber can only be grown at a profit on the more productive sites with relatively short rotations. If the value of a processed product is used as output, the probability of reasonable profit from investment is considerably improved. If the social implications of employment in local industries and nationwide requirements for fiber and construction materials are considered, the problem enters the realm of socio-economic studies. We believe the subject deserves critical examination, but we have neither the professional training nor the information needed for such an analysis.

We can, however, comment on the assumption that clearcutting is the only way that the low-yield forests of Wyoming can be logged at a profit. The timber industry is concerned about the magnitude of the criticism directed against clearcutting. The industry feels that a reduction in the acreage of clearcutting would have two effects: The amount of raw material available for lumber and other wood products would be reduced; and alternative harvest methods would increase logging costs. There is no doubt that adjustments by both industry and the Forest Service are needed if environmental values are to be protected and a fair profit from timber realized. Adoption of management practices aimed at improving productivity will help. Such practices may include improvement cutting to increase timber growth, and treatment to insure prompt regeneration of cutover areas.

Much more research is needed to determine the true costs and benefits of management alternatives, including clearcutting. Such study must include some index for the elusive values of recreation, esthetic quality, water, and wildlife. The newly developing field of model simulation and sensitivity analysis in forest planning may open the door for playing computer "games" with synthesized data. But gathering on-the-ground data to evaluate the alternative uses of a forest environment is an awesome task, and accomplishment is years away.

RECOMMENDATIONS

- **Timber sale plans should include silvicultural prescriptions by qualified silviculturists and specific instructions for timber har-**

vest; long-term evaluation of the effects of the prescription should be mandatory.

- In lodgepole pine
  - The Forests should continue to use clearcutting where it is a sound silvicultural harvesting method and in harmony with management objectives for the unit of land.
  - Alternatives to clearcutting, such as seed-tree and shelterwood cutting and overstory removal, should be used where such methods are consistent with the ecological requirements and protection of the species or appropriate to other uses of the forest land.
  - Thinning and sanitation salvage should be used independently or in combination with clearcutting where economically feasible.
- The present limitation on clearcutting in the Englemann spruce — subalpine fir type should be continued until satisfactory regeneration practices have been developed.
- The Forests should consider using a light selection cutting or "pussyfoot logging" on low-yield sites.
- The Experiment Stations should vigorously carry out research to classify and define plant habitats and their ecological potential for both lodgepole pine and Engelmann spruce — subalpine fir forest types in Wyoming.
- Forest Service Research and Administration should speed up action to develop systems for analyzing the true costs and benefits of forest management alternatives.

Modifying Clearcutting Methods to Protect the Environment

Even though clearcutting can be demonstrated to be the most generally useful method of timber harvest in the Wyoming National Forests, objections to it are not likely to disappear until clearcutting practices have been modified. In planning and executing clearcuts, the protection of other values must be much more evident than it has been. Primarily, such protection implies decisions on location and size of clearcuts and on details of operation that will reduce conflicts. Awareness of the nature of these conflicts is essential.

Our talks with Wyoming residents made clear that they are concerned that clearcutting may have damaged a variety of resources. Often they could not specifically document what had been changed or how the change occurred. Nevertheless, these charges cannot be ignored when appropriate studies have not been conducted to answer many of the questions posed. It is necessary to examine the areas of potential damage and determine ways of protecting the environment, and perhaps even improving it, through intelligent planning.

CHOOSING TIMBER HARVEST AREAS

Many of the planning errors that led to poor choice of timber harvest areas during the 1960's are now being corrected. Nevertheless, techniques of multiple use planning still vary between the two Regions, and criteria for weighing resource values and land use management alternatives are not yet satisfactory. During the 1960's, when timber harvest was accelerated, inadequate multiple use plans, together with incomplete assessment of key values as judged today, resulted in a variety of unacceptable management actions. The Forests are making progress in multiple use planning, and some of the plans are well conceived. Nevertheless, we do not believe that even current plans give proper weight to values other than timber production.

The methods used for selecting timber harvest areas must be modified to consistently recognize all relationships among adjacent drainages. Specific effort is needed to see that other management options are not eliminated by decisions to harvest timber. Truly productive timberland should be identified, but the value of areas that are important to wildlife, watershed, landscape, or recreation should also be properly assessed. Even though every timber sale includes provisions that minimize specific damage to other values, these are essentially compromises. There may be many areas in which there should be no compromise, and therefore no timber harvest.

DETERMINING SIZE OF CLEARCUTS

Decisions about size of clearcuts are basic to multiple use management. There is no simple

Figure 5. — Insect control and timber salvage have resulted in this extensive clearcut. (Moose Creek, Bridger National Forest)

formula for size, and choices must reflect the relative value of the resources to be protected.

All four Forests were observed to have examples of excessively large clearcuts. In some places, stands lying between or adjacent to large cuttings were removed, producing openings of over 1,000 acres. These are large by any standard, but we heard many diverse opinions concerning size. One opinion was that a small block was one of 10 acres or less, another 50 acres or less. Again, we heard that a 35-acre unit was very large.

Let us define some arbitrary size limitations so that we may talk about large, medium, or small units. Let us say units 5 acres or less are small, between 25 and 50 acres, medium, and 100 acres or more, large. The gaps in the categories seem necessary to emphasize contrasts between various units. The small units would thus have reasonably good correspondence with current group cuttings in subalpine fir and spruce. Medium units conform generally to current recommended or regulated size for lodgepole pine clearcutting. In some instances, large clearcuts may be acceptable by reason of their resemblance to natural openings in large-scale landscapes.

There is little justification for clearcuts ranging up to 1,000 acres. Most of the very large clearcuts we saw were a result of attempts to control insects and salvage infested stands. We observed excessively large clearcuts on the Moose Creek Sale on the Bridger Forest (fig. 5), the Wiggins Fork Sale on the Shoshone (fig. 6), and the East Fork Sale on the Bighorn (fig. 7). It was obvious to us that timber management planning on these older sales (late 1950's and early 1960's) was more concerned with controlling insects and salvaging trees than with the effect of clearcut size on landscapes, wildlife habitat, or regeneration prospects.

No 1,000-acre clearcuts are being made now. Timber management plans generally limit clearcuts to 35 to 40 acres. However, existing timber sale contracts call for larger clearcut blocks, and the limit will be exceeded until these older contracts expire or are modified.

We interpret the more recent timber management plans as an intention to eliminate large clearcuts. The aim is not only to aid natural regeneration, but also to allow flexibility in fitting timber harvest to variations in stand conditions, topography, and other land uses.

RECOMMENDATION

- **Clearcut size limits must be determined by the resource values to be considered and by the specific characteristics of the harvest area.**

PROTECTING WATERSHEDS AND FISHERIES

The potential effects of clearcutting on watersheds and fisheries were variously described by Wyoming residents. Some people fear that clearcutting will increase spring peaks of snowmelt runoff and the resulting streambank erosion, thereby reducing the quality of

Figure 6. — Large clearcuts at the road foreground and beyond visually degrade this entrance to the Stratified Primitive Area. (Wiggins Fork, Wind River, Shoshone National Forest)

Figure 7. — A road takes the traveler along the edge of this large-scale clearcut giving him a mediocre viewing experience. (East Fork, Tongue River, Bighorn National Forest).

water. Others believe that the volume of late summer and fall streamflow may be reduced sufficiently to damage fishery habitats. Still others believe that annual water yield may be decreased to the point where supplies are inadequate for irrigation and other uses. These fears are understandable in the absence of appropriate studies in any of the four Forests. Some valid inferences about streamflow behavior in these forests as a result of harvesting timber can be made, however, from research in lodgepole pine and spruce forests elsewhere.

Water Yield Characteristics

Unquestionably, the streamflow characteristics of a watershed can be changed by clearcutting. Hibbert (1967) reported results from worldwide research on effects of forest cutting and reforestation on water yields. Thirty-four studies were in the United States, and five of these in the southern and central Rocky Mountain areas. Both the worldwide and Rocky Mountain studies demonstrate conclusively that reduction of forest cover increases the total amount of water yielded as streamflow whereas reforestation decreases it. They indicate that the practical upper limit of water yield increase is about 1/6 area-inch per year for each percent reduction in forest cover, but most cutting treatments produce less than half this amount.

Strong evidence exists that streamflow response (increase) is proportional to change (decrease) in forest cover. As a new forest grows following cutting, the increase in streamflow declines. For example, 39 percent of the lodgepole pine timber was clearcut from a 714-acre watershed in Colorado that normally yielded 12 area-inches of runoff. As a result, annual streamflow was increased approximately 7.5 area-inches from the area of timber cut, an amount equivalent to 3 area-inches from the entire watershed. Most of this increase appeared during the spring snowmelt runoff period, but some also came in summer and early fall. Erosion and sediment production associated with these streamflow increases were negligible (Goodell 1958). Similar streamflow increases occurred from a 485,000-acre watershed in Colorado, where 80 percent of the spruce timber on 30 percent of the area was killed by bark beetles (Love 1955).

Some people expressed the opinion that the streamflow of the Wind River above Dubois, Wyoming, has been declining as a result of logging. The upper Wind River drainage above Dubois occupies 422,760 acres and yields an average annual streamflow of 341,900 acre-feet. This is equivalent to nearly 10 area-inches of water. During the period from 1963 through 1967, when most of the timber cutting occurred in this drainage, about 5,000 acres were clearcut. Assuming increases in water available for streamflow were comparable to those from high-elevation lodgepole pine and spruce forests in Colorado, this timber cutting in the Wind River drainage could be expected to increase the average annual streamflow for the first several years after cutting by approximately 3,100 acre-feet, or less than 1 percent. Consequently, it is not likely that clearcutting in the Wind River drainage during this period caused any decreases in streamflow. It is also highly unlikely that any streamflow increases that may have resulted from clearcutting were large enough to add measurably to streambed scouring or channel bank erosion on the main Wind River.

On the other hand, it is quite possible that spring snowmelt runoff from small tributary drainages that are a few hundred acres or less and are clearcut over substantial areas, could have been increased sufficiently to cause local scouring and streambank erosion. We recognize this possibility, but although we observed sediment entering tributary drainage channels as overland flow from roads, nowhere did we find tributary stream channel scouring or streambank erosion directly traceable to increased runoff from clearcut areas.

Recently, the four Forests restricted to 30 percent the proportion of a drainage that can be clearcut at any one time. Such a restriction is, no doubt, a step in the right direction, but the 30 percent figure is largely just a guess. The sizes and conditions of watersheds to which this restriction should apply are still to be defined by research.

Many studies have been made to determine the effects of logging on the quality of streamflow from forests. This research has shown that undisturbed forests produce very small amounts of sediment and the streamflow is generally suitable for drinking. Further, except for

possible increases in streamflow temperatures and some increases in streambank erosion caused by higher streamflow peaks, the simple felling of trees does not affect water quality adversely. On the other hand, skidding of logs from forests can sometimes increase sedimentation considerably, depending on the location of skid trails, how well they are drained, the erodibility of soils, and rapidity of recovery of vegetation on skid trails. We saw little actual sediment damage to water quality in streams as a result of logging *per se*. In several instances — for example, in Jules Bowl on the Shoshone National Forest (fig. 8) — we encountered potential for damage to streamflow quality in the form of logging residue clogging stream channels. Current timber sale operating requirements include leaving a strip of uncut forest along live stream channels, where possible, and keeping logging residue out of stream channels. These requirements should be strictly fulfilled.

The necessary knowledge about the kinds and sizes of areas and proportions of watersheds that can be logged without creating hydrologic damage will not be acquired overnight. Meantime, the technical knowledge that specialists in soil, hydrology, and other disciplines can furnish could be more effectively used than it has been in the past in planning timber management operations.

Research and experience in many places have shown that none of man's activities in forests contribute more to poor water quality in streams than roads, especially roads that are located too close to streams, built on too steep grades, and inadequately drained. Our observations confirmed that roads are the greatest man-caused source of stream sedimentation in the Forests. The problem is discussed more fully in the section "Roads."

Fisheries

The biological characteristics of aquatic life and fish environments are very closely related to conditions in the surrounding watershed. Flow quantity and patterns, water temperature, chemical quality, and other conditions important to aquatic ecosystems and to fish are directly or indirectly affected by timber harvest activities. Shaw and Maga (1943) determined that the hatchability of trout and salmon eggs decreased from 16 percent to 1 percent as a result of 2 to 4 hours exposure to suspended sediment of 1,178 to 1,380 parts per million. Bartsch (1959) found that an increase in stream turbidity from 5 to 1,700 parts per

Figure 8. — Logging residue clogs this tributary drainage channel. (Jules Bowl, Brooks Lake, Shoshone National Forest)

million reduced bottom fish food to almost zero, but as turbidity decreased progressively downstream to 17 parts per million, fish food increased to normal levels. The direct effect of sediment damage to fisheries appears to be the killing of fish food and eggs. Less commonly known are the effects on aquatic ecosystems of oxygen-demanding organic matter that is adsorbed on sediment to create anerobic stream bottom conditions, or of eutrophication of streams that may result from increased movement of soluble mineral and organic nutrients away from forest sites where soil and vegetation have been disturbed by logging. These biological relations of forest uses to aquatic environment have only recently begun to be investigated. They need greatly increased research attention.

RECOMMENDATIONS

- **More and better use should be made of the knowledge that specialists in soil, hydrology, and related areas can furnish in planning timber management operations.**
- **Timber sale contract requirements providing for protection of live stream channels from unnecessary disturbance and from clogging with logging residue should be strongly enforced.**
- **Research should determine (a) the kinds and sizes of areas and proportions of watersheds that can be safely clearcut at one time without creating damaging changes in streamflow quantity, quality, or timing; and (b) the nature and magnitude of changes in onsite nutrient content and of eutrophication of streams that may result from soil and vegetation disturbances that attend timber harvesting.**

PROTECTING WILDLIFE

In Wyoming the term "wildlife" describes both a large variety of species and incredible numbers of some species. In the comments we heard about damage done to wildlife resources, however, either fisheries or elk were usually implied. Here, and elsewhere in this report, discussion of specific problems of wildlife is concerned primarily with elk because they are the focal point of public interest. The welfare of elk, deer, and moose is important to the economic welfare of the State; business activity accompanying the hunting season has reached amazing proportions. At the same time, lesser creatures like the chipmunk and Canada jay are ecologically significant in the forest environment that attracts so many visitors to Wyoming. Even though our discussions are limited to big game, we believe concern for wildlife properly extends over a broader spectrum that should be more generally recognized.

Damage to wildlife habitat from clearcutting could take a number of forms. Wild animals have only a few basic environmental requirements: food, water, and cover — including places suitable for feeding, hiding, resting, playing, and raising young. A productive habitat is one in which these requirements exist in proper juxtaposition and are available when needed. Any disturbance that destroys one of the requirements or the spatial relationships, or prevents habitat use by animals, can be considered detrimental to wildlife.

Whether clearcutting can create such disturbances is not clear. The evidence is inconclusive because job quality varies greatly and because timber harvest is accompanied by roads that could be detrimental even where cutting is potentially beneficial. The discussion presented here considers only logging with adequate cleanup. The additional problems of logging residue and roads are treated elsewhere in this report.

We can start with the basic premise that closed-canopy, mature forests do not support an abundance of wildlife (Schneider 1970, National Academy of Sciences 1970, and others). Much of the existing forest in Wyoming fits this description; understory vegetation is shade grown, sparse, and unproductive. Some overmature lodgepole pine stands, for example, produce no food and only marginal cover, and may be barriers to big game movement (fig. 9). Nevertheless, the total Wyoming forest environment is extremely productive because it includes an interspersion of natural grasslands, meadows, and parks. These openings provide a grass and forb diet favored by elk and within a short distance of cover. In Arizona, Reynolds (1962) found that elk actually spend more time in the openings than along the borders or in the adjacent forest. Juxtaposition of cover types is certainly not perfect in the Wyoming mosaic, but it would be extremely hard to cite a better

Figure 9. — Understory vegetation is lakcing in this overmature stand of lodgepole pine, and down timber may restrict movement of big game. (Poison Creek, Bighorn National Forest)

example of naturally productive habitat for big game.

The question, then, is whether this already highly productive habitat can be improved or whether environmental manipulation simply adds unnecessary openings and destroys existing habitat relationships. We saw only a few large blocks of undisturbed timber with no natural or manmade openings. Where forest cover had been removed, however, forage production — in grass and forbs — was increased. Such benefit to big game has been documented in a wide variety of forest habitats.

It is extremely unlikely, however, that openings larger than about 40 acres can be considered an improvement for big game. Despite general use of meadows and open parklands by elk (Stevens, 1966) and historical records of elk migration to the plains (Murie, 1951) the favored openings in the forest are probably quite small. Reynolds (1966a, 1966b) found that openings larger than 20 acres in spruce-fir and 40 acres in ponderosa pine forests were used less frequently than smaller openings by both elk and mule deer in Arizona. A similar scale is suggested by Wallmo (1969) for Colorado mule deer. How far Wyoming elk will venture from cover must be determined from behavioral studies. It is probably reasonable to suggest, however, that until appropriate research has been done, clearcuts should be no larger than 40 acres and no closer than 200 feet to existing openings.

Properly designed clearcuts can be used to provide productive forage areas for big game and thereby increase the basic carrying capacity of Wyoming big game ranges. Past forest management has not been particularly sensitive to this potential or to the possible effects of removal of cover from existing habitat. Before the mid-1960's, wildlife was apparently not even a consideration in the attempts to control beetles by cutting. Clearcuts on the upper Wiggins Fork (see fig. 6), for example, funnel a normal elk migration route into a very narrow timber belt at the base of a rocky slope. If wildlife had been considered in planning, the increased vulnerability of these elk during the hunting season might have been recognized and a different sale layout chosen.

Another evidence of past failure to recognize wildlife values is the treatment of small potholes and ponds. Although the importance of such ponds to moose or elk is not well

established, we believe they are desirable. We observed several of these ponds (see fig. 3) logged over and filled with debris. We were told that they are far too numerous to be located and protected. Our observations in the uncut strips confirmed their abundance, but with planning, the effort required to leave a patch of protective cover around ponds would not be prohibitive.

Clearcuts made in recent years reflect a constructive attitude of administrative personnel and improved multiple use guidelines. We examined a number of cutting areas in which blocks had been arranged, or stringers of timber left, to provide travel lanes for deer and elk. We saw a few timber sales in which uncut patches had been provided for escape cover, and we consider the current trend to smaller clearcuts beneficial to wildlife. A more direct and positive approach to wildlife protection is needed, however. There is an expressed desire to upgrade wildlife management on all Forests, but habitat manipulation in Wyoming is essentially mitigation of unfavorable effects rather than specific action to improve. Despite the extremely high value of the wildlife resource in Wyoming, it still holds a secondary position in some land management decisions. Lack of funds is one reason for this. The Forests, for example, make specific effort to protect calving areas and migration routes on the recommendation of Game Department or Forest biologists, but they are not currently financed to identify such areas in advance of timber harvest.

Forest personnel are acutely aware of both the potential for improving wildlife habitat and the lack of information to assist in realizing that potential. This is not a problem that can be solved by budget allocations alone. More than money and manpower, the Forests need information. Research already underway in Montana, Oregon, and elsewhere will help, but positive action by the Forests is also possible. We interpret the provisions of Title 1 of the Environmental Quality Act of 1970 and Executive Order 11514 to mean that timber management funds can be used in monitoring the effects of timber harvest on other resource values. The importance of the wildlife resource and the potential for conflict make such action mandatory.

RECOMMENDATIONS

- **Until more specific information becomes available, clearcuts in big-game habitats should be limited to 40 acres and should be no closer than 200 feet to existing openings.**
- **Research and monitoring of wildlife behavior as affected by timber harvest should be encouraged in Federal and State agencies.**
- **Unless wildlife budgets can be substantially increased, the costs of evaluating effects of timber harvest on wildlife should be properly considered a part of the timber harvest obligation.**

PROTECTING RECREATIONAL OPPORTUNITIES

The unusual opportunities for outdoor recreation in Wyoming give the Forests special value. Any damage to the quality of the forest environment may adversely affect recreational values.

The management responsibility for recreational values is difficult to define. Recreation as a concern of National Forest administration is entering a new phase as increased population pressure brings new demands. It is clear that the protection of trees, water, soils, and wildlife will enhance recreational values. Of more direct concern, however, is the scenic quality of the landscape as seen from roads and trails and even from the air. Provision of recreational facilities is another necessary element in overall planning. The broad aim is to give the forest user the opportunity for a satisfying outdoor experience as he travels on foot, on horseback, or in a motor vehicle, depending on his taste and the kind of forest area he has chosen.

Grand Teton and Yellowstone National Parks absorb much of the tourist and camper traffic, but the Forests also receive a considerable share. The scenic quality of the landscape as seen from roads through the Forests and from the air is very evident to visitors and residents alike. More particularly, the Forests are highly attractive to those who prefer undeveloped areas for their forest experience. The four Forests have a larger percentage (34%) of Forest System in Wilderness and Primitive Areas than any other National Forests in the United States: nearly 2.4 million acres of undeveloped backcountry, including the tallest peak (Gan-

nett Peak) and some of the most spectacular scenery in Wyoming.

Many residents believe that wild-country quality is being degraded by timber harvest. Since high-speed logging and large-scale cutting operations are relatively new, the recollection of how things once were is fresh in their minds. They tend to use the National Parks and Wilderness Areas in National Forests as standards of comparison for Wyoming wildlands. This leads to a strong conviction that timber harvest is destructive to recreational opportunity, even though the destructive processes are not clearly definable.

A citizens' group we met with in Jackson, Wyoming, held this view but could not define the kinds of damage sustained, or, after separating wildlife and scenery, define the activities they consider to be recreation. The confusion is widely shared. Forest Service estimates of number of visitor days are not sufficient to provide badly needed information on what outdoor recreation needs are, how those needs can be met, or what the management alternatives are. Such information is essential to quality recreation management.

There is some direct evidence that conflict of values has not been recognized adequately in management decisions affecting recreational opportunities. A specific complaint, commonly heard, was that clearcuts are detrimental to established trails used by hikers and riders. At Jim Creek (see fig. 2) and Willow Creek on the Bridger National Forest, at Jules Bowl on the Shoshone, and almost everywhere on the north side of Wind River Valley, we observed or heard about trail access that had been destroyed by clearcutting. Some trails were converted to roads that terminated in cutting blocks and slash piles; others were simply obliterated. Most commonly, however, the stand adjacent to an established trail was clearcut, and passersby were forced to observe the result.

On some sale areas, recreation values were coordinated with the timber harvest. On the Teton Forest, for example, the foot trail to Goodwin Lake starts at a trail head in the Curtis Canyon clearcuts. Hikers using this trail walk along the edge of a cutting block some 200 to 300 yards before entering the uncut forest. The Forest provided adequate parking space and cleaned up the logging residue along the

Figure 10. — At the access point, this trail has been cleaned up after timber harvest. (Goodwin Lake Trail, Teton National Forest)

trail (fig. 10). The hiker has a clean trail, forest on his left, and a pleasant meadow on his right. In a very few years this meadow will be converted into a young stand of lodgepole pine.

The major disadvantage of this technique is that cleanup must be very thorough if it is to be effective at all. From a scenic standpoint, the center is the very worst place from which to view a clearcut. The edge is somewhat better, but from a foot trail almost any close view is likely to be disheartening. A much better course would have been to use the landing area to provide parking but route the trail into the forest so the manmade meadow would be only perceived rather than endured.

Current multiple use plans do contain safeguards that recognize the potential conflicts between existing trails and timber harvest. Nevertheless, we are uncertain that the total magnitude of the problem has been recognized on any of the Forests. We believe the Forest Service recognizes the significance of recreation on the National Forests in Wyoming, but recognition alone has not provided proper coordination in management planning.

On several cuttings we observed, recreation was obviously not even considered when the timber harvest was planned. We received unconfirmed verbal reports of outfitters whose business had suffered substantially because the trails they had been using were logged out and no longer provided the kind of outdoor experience desired by their clients. It might be said that the loss by the outfitter was balanced by the gain by the logger, and the loss of the trail by the gain of a road accessible to vehicles. We question, however, whether such a trade-off was really necessary. Proper planning with recognition of key resource values should have made it possible to have all three: the timber, the road access, and, for those who prefer it, access by horseback. Recreation should be a key consideration in every land management decision on the four Forests.

The provision of recreational facilities, as a responsibility of the Forest administration, is a growing problem as population pressures rise. We found that recreation budgets on the Forests were of the same magnitude as the timber budgets, but this is apparently only adequate for maintenance. The Bighorn Forest has received no money for recreation construction in the last two years, and the other Forests are not much better off. On every one of the Forests we encountered "throw-down" campsites without adequate waste disposal facilities, water, or fireplaces. Such campsites are a source of environmental pollution and fire danger and create additional pressure on already strained recreation budgets.

Here the solution is not necessarily better planning, because the Forests do have plans for additional campgrounds. Construction money would be helpful, of course, but better understanding of the total picture is also needed. The Forests need more information describing saturation levels for people or tolerance of land for this kind of use. The campground problem is only one example of the lack of information necessary for comprehensive recreation management. The Forests also need basic survey information on trail use and its implications for the future. Most existing trails were designed for uses other than recreation. Trails could be so designed as to enhance recreational opportunity, including scenic quality, whatever their other uses might be. Some of our recommendations on design and construction of roads apply to this problem, but we know of no current research in this area.

Finally, we believe the lack of adequate recreation information prevents imaginative solutions to management problems. There are many situations in Wyoming where timber harvest is limited by topography to sites already occupied by trails or suitable for campgrounds. Once the timber harvest option is selected, other options may become quite limited. We do not believe the Forests always have information enough to make the best judgments of management alternatives. Too little is known about the desires and needs of recreationists and the components of recreation experience. In the absence of such information, even an acceptable decision may result in the loss of a better alternative.

RECOMMENDATIONS

- **Multiple use planning should give particular attention to the long-term effects of timber harvest in limiting the options for future recreational use of land.**
- **The Regions should encourage research that will help the Forests to achieve compre-**

hensive recreation management appropriate to the desires of people and the potential of the land.

PROTECTING SCENIC QUALITY

The protection of scenic quality in the landscape may seem to be totally incompatible with clearcutting. But if the cutting has been properly located, designed, and carried out, the landscape can recover its pleasing aspect within a relatively short time.

The tendency of Wyoming residents to equate general landscape quality with wilderness quality is unrealistic. Parts of the four Forests have been altered and will be altered in the future, and this is a proper use of the forest resource. The aim must be to see that dominant characteristics of forest land remain intact, in spite of specific changes. Manmade intrusions, though evident, can be fitted into the framework of the landscape and express a basic sympathy for it. If a cutting is designed to correspond to or blend with the natural features of its surroundings, it need not dominate the landscape as an alien element.

This report emphasizes that a new kind of comprehensive planning is needed in which the integrity of the landscape is observed. The end products of timber harvest should be the result of intention and not chance. This concept can be expressed particularly in the visible landscape. Landscape architects can be helpful in presenting visualizations, including graphic representations, based on pooled professional knowledge. Unquestionably more professional help would strengthen this effort, and the need for special training is urgent. Such training should include making landscape (or scenic) inventories,[2] coordinating changes in landscape resources through design, and predicting, verbally and graphically, the visual impacts of alternative solutions upon the landscape.

Whatever the mistakes of the past, there is no reason why clearcutting must necessarily degrade the quality of the landscape. If the various attributes of clearcuts — size, shape, location, and dispersion — are handled with understanding, scenic values can be protected.

Size

Large size cuttings have been widely criticized, but under some circumstances they can be acceptable. Observed from a distance, a large cutting can fit the scale of the country, appearing as a placid element that draws little attention to itself (fig. 11).

---

[2] *Elements of the scenic landscape can be concretely documented through the use of a number of inventory techniques. See Litton 1968.*

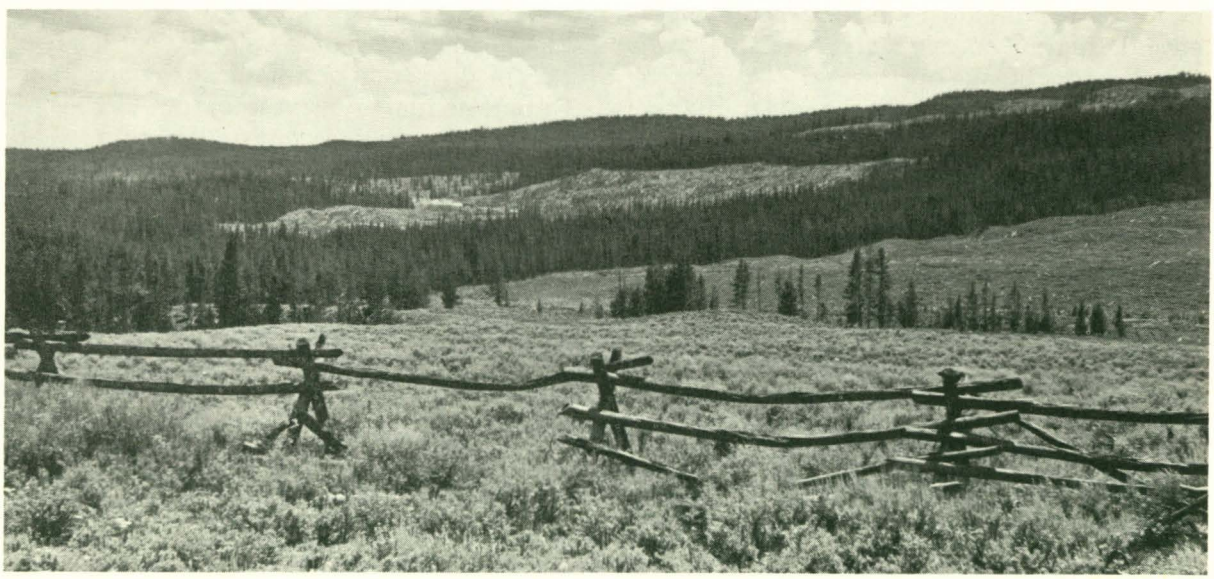


Figure 11. — In this highway view at a distance, the large-scale harvest pattern is compatible with the landscape. (Sheridan Creek, Shoshone National Forest)

There are obvious defects, however, in the appearance of large cut blocks as seen from a point close to or inside the block, as at Sheridan Creek (see fig. 1). In another example, the natural pattern of openings and forest stand combinations in the Bighorn happens to be one of large scale, suggesting that larger harvest areas are appropriate; but this is country with gentle, sloping terrain, and cuttings are seen close by rather than from a distance (fig. 12). From inside this clearcut, the landscape is dominated by slash, there is little evidence of regeneration, and nothing of interest is to be seen. Furthermore, the clearcut suffers by comparison with the large natural meadows of the Bighorn with their crisp forest edges.

In large cuttings, leaving groups of trees could result in improved visual effects, as well as lead to solution of associated problems of resource protection, as the Antelope Mountain timber harvest, Teton National Forest, suggests (fig. 13).

In clearcuts on all four Forests, tree clumps could have been left related to local features such as erratic boulder groups, outcrops, minor topographic eminences, ponds, or the like. Yet, typically these concentration points of visual interest were treated as though they did not exist (figs. 14, 15). It would have been better to recognize that such small features do contribute positively to the richness of the landscape. If an even-age management system is to be sensitively adjusted to the native nuances of the landscape, management must be more intensive than any yet to be seen in the four Forests.

Limitations of cuttings to medium size, although recommended for a variety of reasons (such as wildlife protection) can result in a complicated, pocklike effect, drawing attention away from the surrounding country. The cuttings in the Teton Forest, seen from Mount Baldy near Spread Creek (fig. 16) are an example. Their appearance approaches spottiness as relationships between cuttings and terrain become confused. Such harvest areas can be visually successful, however, when their size (and shape) can be clearly related to landform elements such as a whole hill, a ridge face, or a bowl. The size (medium or otherwise) should reflect an observed characteristic of vegetative pattern or terrain. Where a medium-size block is isolated in comparatively large-scale surroundings, it threatens unexpected dominance over the scene. Furthermore, even though a single clearcut may appear appropriately related, there is no assurance that a series will follow suit. The medium-size unit, presently encouraged by management, has a potential of greater disruption to the landscape than either large or small units. There is need for variety

Figure 12. — This close-in view of a large clearcut on gentle terrain is monotonous and devoid of interest. (Caribou Mesa, Bighorn National Forest)

Figure 13. — A group of residual trees within a harvest area provides visual interest. (Antelope Mountain, Teton National Forest)

that intermediate-size units cannot provide alone.

Small cuttings have good likelihood of being visually "absorbed" in their surroundings. On moderately or gently sloping land surfaces, the chances are high that the floor of the cut will be screened by the vertical edge of the block. Where a honeycomb effect of numerous small openings occurs, the visual demand would be slight and subtle. Such a condition would closely resemble a sparse stand.

The problem of size is not solved by simply determining that large, medium, or small is good, bad, or indifferent. Under some circumstances the large unit might well be the best-appearing unit; however, special steps must be used to overcome its disadvantages. If only medium-size units are used, problems of monotony and questionable fit to landscape may develop. The basic solution for esthetic and visual compatibility must come from variety, based upon careful observation and understanding of the landscape in which changes are to be made.

Shape

The shape of clearcuts has prompted almost as much public criticism as their size. In the clearcuts made during the mid-1950's, seldom, if ever, was there any specific harvest management plan for the reserved blocks. Convenient but arbitrary straight-line boundaries for cutting units were commonly used, resulting in rectangles or other shapes that largely ignored the relation of the cutting to landform, to windthrow, and to adjacent stands of timber that would be harvested in the future.

Rectangular clearcuts in the Fish Creek area on the Teton National Forest have called forth much comment (fig. 17). These cuttings are easily viewed from the air by travelers going to and from Jackson, and they dominate the land-

Figure 14. — The visual value of this outcrop could have been recognized and a small group of trees left around it. (East Fork, Tongue River, Bighorn National Forest

Figure 15. — Tree groups around these erratic boulders could have provided landscape interest within the cutting. (Little Flat Top, Bridger National Forest)

Figure 16. — In these medium-size cuttings, the relation between cutting pattern and terrain is somewhat disordered. (Spread Creek, Teton National Forest)

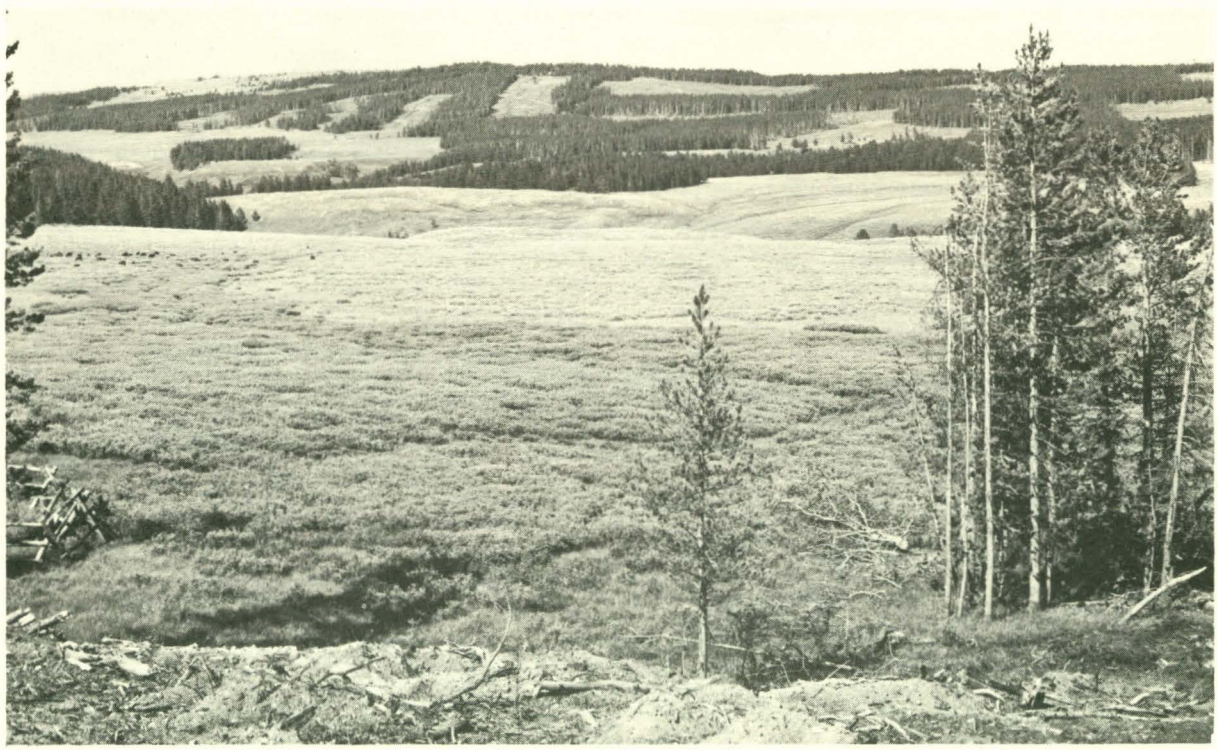


Figure 17. — A basketweave cutting pattern is seen here in conflict with a dominantly horizontal landscape. (Fish Creek, Teton National Forest)

Figure 18. — Natural open strips in diagonal order characterize this landscape. (Lander Peak, Bridger National Forest)

scape by their geometry and their extent. Their fault is not so much that they are obviously manmade as that they fail to fit the land and be sympathetic with it.

Geometric shapes are not all manmade nor are they necessarily in conflict with the land. Note the diagonal linear escarpment running on the shoulder of Lander Peak in the Bridger (fig. 18). Here much of the front forest margin is also straight. Several strip cuttings repeating the theme of the natural opening would appear coordinated with this particular landscape. Also in the Bridger, straight-edged avalanche paths, oriented perpendicular to slope, may be seen in figure 19. The avalanche paths constitute a model for the design of cuttings with a linear relation to the landscape. Here the pattern of cuttings is also well designed and dispersed. Such examples do not necessarily make straight-line geometric units right, but neither do they make them unacceptable.

Strong native patterns are encountered in the Rocky Mountain country, such as typical lens-shaped faces of open grass or sagebrush seen in contrast to densely forested faces. Furthermore, natural openings tend to be connected to one another or to repeat a characteristic relationship to topography or exposure. These characteristics have been little recognized as models for cutting patterns.

In all the Forests visited, we heard that the present model for cutting shape was "irregularity." This has no clear or simple meaning — shape has to be related in some satisfactory way to the land on which it occurs. Yet there is an indication here of promise, a step in the right direction. Irregularity and variety in cuttings suggest more than esthetic compatibility. Visually pleasing clearcuts may also prove to be ecologically sound with respect to wildlife habitat.

Location

The more conspicuous a cutting is, the more perfectly it must be designed. A hierarchy of locations can be established to help predict how conspicuous cuttings will be.

The least obvious position for a cutting is at or near the visual base of a forest, especially if it is adjacent to and parallel with an existing bor-

Figure 19. — Both natural snow slide openings and a pattern of well-dispersed manmade openings combine here in an orderly way. (Meadow Cabin Creek, Bridger National Forest)

derline between dissimilar plant communities (such as a tree-grass junction). An example is the "nibbling" technique used in the Teton Forest, Spread Creek country, in which certain of the cuttings are pared off timber stands adjacent to sage or aspen areas (fig. 20). Low visibility also results if a cutting is designed as perimeter enlargement of an existent opening or a type change.

Both "nibbling" and perimeter enlargement, however, may cause difficulty in regeneration since the cutting crosses the edges of dissimilar plant communities. The Copper Creek sale, Bighorn National Forest (fig. 21) was cut through to meet existing grassland. A brief botanical survey suggests that the former forest understory has been converted to grassland; such understory plants as arnica and huckleberry are almost completely replaced by grass-forb meadow components (fig. 22).

The second and more obvious position for a cutting is at the center of a forested face (see fig. 11). It is conspicuous because the lighter color of soil or grass-forb cover contrasts with the darker surrounding forest. Winter snow emphasizes the difference even more strongly. Also, by its isolation, a cutting in a central position is more noticeable. The effect of isolation or strong contrast can be avoided if the cutting is connected with pre-existing lines or pattern edges, such as margins of different-aged stands or differing plant communities.

The most conspicuous location for cuttings is along the upper parts of ridges and especially the skyline. At the skyline, there is maximum contrast between the dark landform contours and the light void of the sky (see fig. 4). The Cartridge Creek sale on the Shoshone National Forest (fig. 23) demonstrates at close hand how cutting lines stand out as they cross over a ridge. Scattered leave trees, perhaps damaged or leaning, are visually degrading on the sky silhouette, and should be removed. Frequently, a better solution is to leave a tree edge that comes down over the crown of the ridge. This treatment expresses the natural coordination between a timbered backslope and an open face or patch as exemplified in figure 24. The tear-

Figure 20. — A "nibbling" technique builds on natural pattern by cuttings at the stand margin. (Spread Creek, Teton National Forest)

Figure 21. — Timber here was harvested up to the adjacent grassland. (Copper Creek, Bighorn National Forest)

Figure 22. — Difficulties in regeneration may develop when the "nibbling" technique is used. The forest understory (left) of arnica and huckleberry was converted to grassland (right) by clearcutting. (Copper Creek, Bighorn National Forest)

drop shape of the natural glade echoes the upper silhouette of the hill and the linear escarpment across it.

Cuttings are especially conspicuous in areas associated with water or scenic landform features. These special areas tend to be the focus of recreational use. Cuttings in such areas, unless done with the greatest care, suggest only disregard for esthetic and recreational values. Water assumes certain of the light qualities of the sky and is seen against the darker solidity of forest or land surface. This visual contrast is yet another reason to treat riparian and water-dominated areas with great care. A cutting in the Teton National Forest shows evidence of sensitive response to an existing pond (fig. 25). Scenic features such as Pinnacle Buttes near Brooks Lake, Shoshone National Forest (fig. 26), similarly make any cuttings in their vicinity more obvious.

Cuttings located near existing roads are, of course, highly conspicuous. No road exists in isolation from its surroundings; it also includes a visual corridor, the view seen from the road. Two examples, as seen from highways, suggest that there was no recognition in the planning stage of the potential effect on the landscape. On U. S. Highway 14, in the Bighorn, the Owens Creek cuttings are displayed in front of the driver as he moves along flat curves and straight stretches (see fig. 4). The cuts stand out on uptilted surfaces that are near the skyline. On the Teton Forest, the Curtis Canyon strip cuts were made during the period 1956-1963. High visibility of the strips from U. S. Highway 26-187 through Jackson Hole was not taken into account in the sale layout. These cuttings dominate the scene because the vertical strips contrast with the horizontal ridges of the surroundings. In fact, had the strips been laid out parallel to the contour, they would not have been visible from the road.

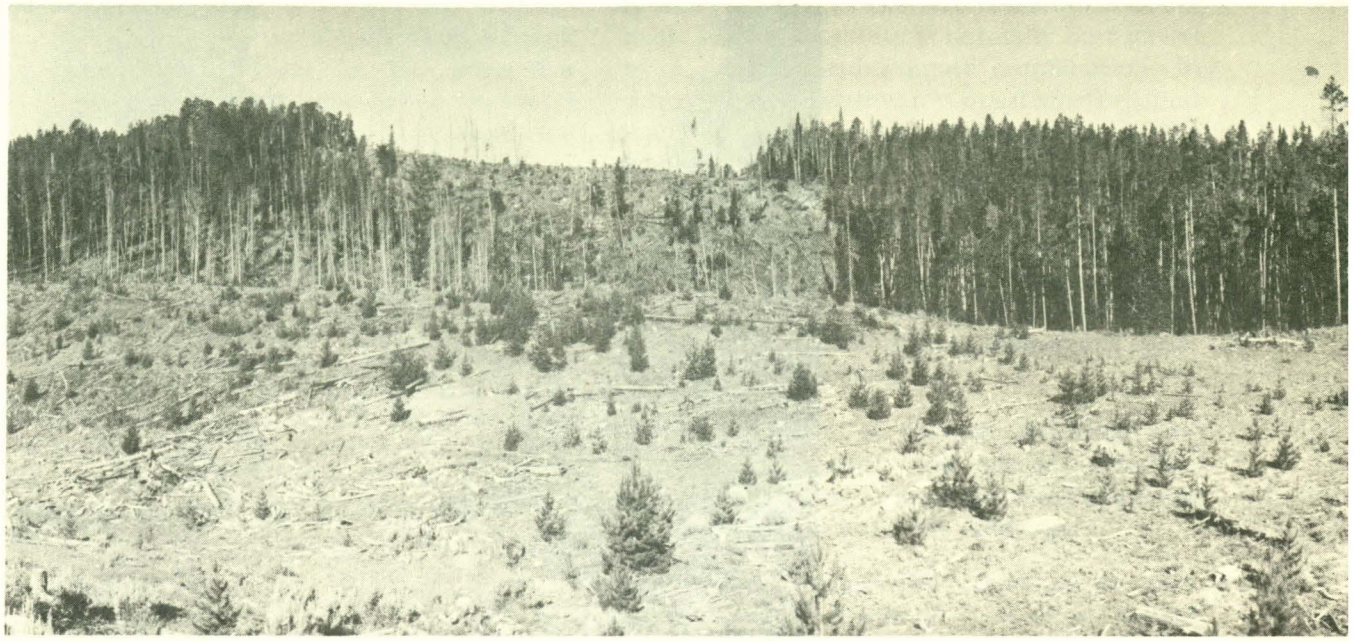


Figure 23. — The skyline is the most conspicuous location for a cutting. Scattered and damaged leave trees are visually degrading. (Cartridge Creek, Shoshone National Forest)

Figure 24. — This natural opening with timbered skyline conforms in shape to the hill silhouette. (Warm Springs Creek, Shoshone National Forest)

Figure 25. — The timber harvest area here is well adjusted to protect a pond. (Lower Spread Creek, Teton National Forest)

The cuts were modified in 1970 to make them visually more compatible with the terrain forms and surface patterns of the larger landscape (fig. 27). The method followed in establishing the pattern-altering cuts should be noted because it suggests a type of control that needs to become routine in sale layout. One of the landscape architects from the Regional Office, working with the Forest timber management staff, produced a number of sketches indicating various ways in which alternatives would appear. Other drawings of visual alternatives were produced by the Pacific Southwest Forest and Range Experiment Station. A solution was selected that served the timber management objectives as well as the aim of compatibility with the visual environment. This kind of procedure should be a standard method rather than an unusual solution to a specifically annoying problem.

Dispersion and Subordinance

The question of proper dispersion of cuttings — the concurrent location of two or more units — requires clarification. Dispersion is a complex problem, involving relationships of size, shape, location, and even time, since design problems arise when one series of cuts is followed by a later series. Unless the whole harvest rotation is planned, the design of the first cutting may make it difficult or impossible to

avoid poor visual images in the second or later cuttings.

In timber sales in the Meadow Cabin Creek area of the Bridger (see fig. 19), some five medium-size cuts were made below the crests of somewhat similar hill forms. The ovoid cuts are appropriately varied in size and shape so that they individually fit the spheroid hills. The immediate landscape thus contains a number of similar openings that contrast with forest cover. This manmade pattern, built upon repetition and variation of existing patterns in the surroundings, creates a desirable dispersion. The total effect is one of subordinating change to the characteristics seen in the landscape.

The shape of the block and strip cuts in Fish Creek, Teton Forest (see fig. 17) has been discussed; the dispersion of the strips also fails to establish any clear relationship to surroundings. Units are linear, suggesting a basketweave pattern with parts in 90° opposition; yet the landscape is essentially horizontal. To follow contours would have established a simple continuity with the dominant direction of skyline and bottom grass-tree line. Additionally, the amounts of cut openings and remaining tree cover are nearly equal. This is confusing visually since neither of the two elements is dominant. Esthetic stability is normally best served by a dominant-subordinate combination. In summary, the dispersion is unsatisfactory, and manmade changes are overpowering in the landscape.

RECOMMENDATIONS

- **The basic character of Wyoming wildlands should be kept dominant, and manmade alterations held subordinate, in design of clearcuttings. To do this**
  - **The design of cuttings, including size, shape, location, and dispersion, should respond directly and specifically to visual characteristics of the landscape.**
  - **Scenic inventories, recording at least dominant landscape resources, should be made to aid in planning and design.**
  - **Forest personnel should be given training to develop greater managerial sensitivity to landscape resource values.**

Figure 26. — Scenic Pinnacle Buttes have been visually degraded by adjacent cutting and failure to clean up logging residue. (Brooks Lake, Shoshone National Forest)

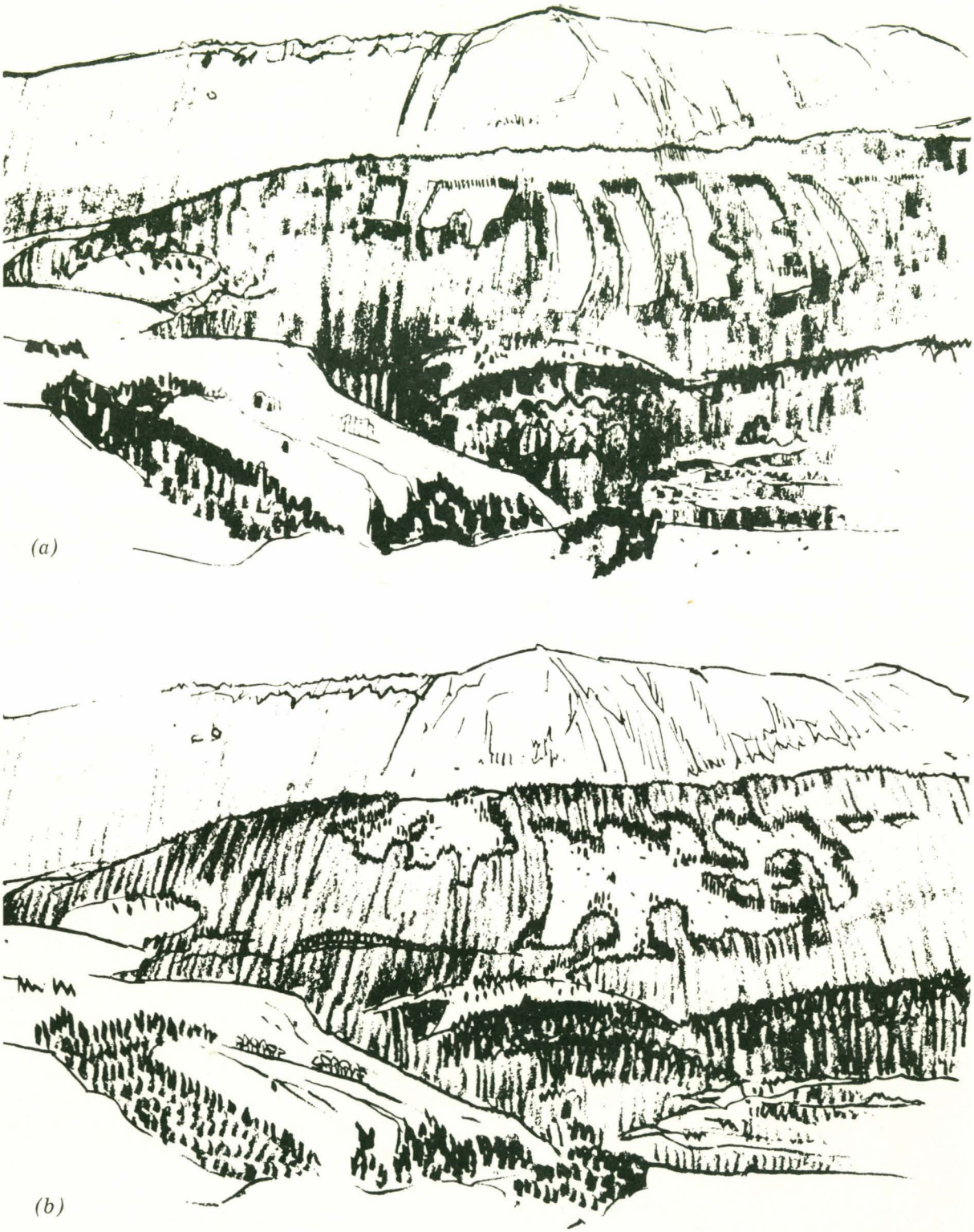


Figure 27. — Strip cuts made before 1964 are shown here in two forms. (a) Field sketch of strip cuts as they were in 1969. (b) Sketch of strip cuts as they were being modified by recutting in 1970. (Curtis Canyon, Teton National Forest)

Roads

Intensive forest management requires roads. They are needed for timber harvest but they serve other purposes as well. Livestock are moved by truck to prevent land damage, and roads provide access to trail heads and campgrounds, as well as other recreational opportunities. During the past decade, road construction has increased on all four Forests. Nearly $14 million were allocated to the four Forests between 1961 and 1970 for construction and maintenance of transportation systems. The new roads built during this period have become a major source of public concern.

Objections to the Forest Service roadbuilding program were expressed to us in many ways. Some people charged that too many roads are being built, that most roads are designed only to tap new timber harvest areas; that roads are detrimental to soil stability, streamflow quality, and fisheries; that roads have adverse effects on big game populations; and, finally, that roads are ugly. As in objections to clearcutting, the belief was expressed that potential long-term irreversible effects of roads on resources other than timber are not receiving proper consideration by Forest managers.

Feelings on this matter are strongly expressed. A few critics classified road construction as an "epidemic disease." Others charged that roads are not planned except as a day-to-day response to industry demands for timber, and that recreation or resource values had been used to justify funding of roads for access to timber where the timber values were too low to justify construction costs.

A large percentage of the roads we examined were well constructed and maintained. As in other management areas, however, there is evidence of inadequate planning for road construction. There has been negligence in some instances. We saw portions of roads that could properly be criticized and we believe that some public concern is warranted.

To clarify the issues here, it will be helpful to examine the functions of forest roads. In general, two very different types of roads are built on National Forests: system roads and temporary roads.

System roads are the permanent transportation routes needed on a Forest to meet all resource management and protection objectives. Usually Forest engineers assist in the location and design of these roads and supervise construction to assure that multipurpose needs are served. The roads are built to standards determined by the resource uses for which they are intended. They may be constructed by the Forest Service or a private contractor. They receive periodic maintenance, and are usually open to the public in most situations.

Temporary roads are not part of the permanent transportation system. They are built to accomplish essentially one-time resource management activities, such as hauling timber from a particular part of a timber sale area or constructing a ski lift, pipeline, or powerline. Most often, these low-standard roads are located or approved by Forest Service officers and built by a private contractor. They are intended to be kept open only for the duration of the activity for which they were built, and then treated to prevent erosion and closed to all traffic.

We believe the discrepancy between principle and practice in the building and maintenance of roads has given rise to most criticism. Effective planning, scrupulous observance of responsibilities of execution, and careful review of management actions should solve most problems.

Road Planning and Maintenance

The roadbuilding associated with increased timber harvesting in the past 10 years has created special problems. These are primarily due to deficiencies in the planning process that should have controlled the roadbuilding. Planning is particularly important in several areas: the level of road density to be reached, the suitability of roads for the purposes they are to serve, and the status of roads as temporary or permanent.

DENSITY LEVEL

A summary of road data for the Forests (table 1) reveals some important facts. First, only about one-fifth of the mileage of existing

system roads on these Forests was built during the 10-year period since 1960. Second, about three-fourths of the temporary roads were built during this same period. The difference largely reflects the increased density of temporary roads needed to remove logs from timber harvest areas. Third, nearly two-thirds of the total mileage of temporary roads ever built on these Forests still had not been closed to vehicular traffic by the fall of 1970. The fourfold increase in temporary roads since 1960 and the failure to close such a large proportion of these temporary roads are sufficient cause for public concern about Forest Service intentions regarding road density.

Each of the Forests has a transportation plan that responds to road needs for the various management functions. For several reasons, these plans seem confusing to us and they were reported to be confusing to the public. For example, some roads do not appear on transportation plans because they are classed as temporary and are not to be retained. This implies to the public, however, that the Forest Service is not aware of already existing roads. The plans also appear incomplete. None indicate a deliberate intent to halt road construction when some specified level of forest access is reached. Forest Service personnel were vague about setting any limit on eventual number and destination of system roads. Criteria for establishing such limits are lacking or not clearly defined. For example, in several places we were shown roads originally planned as temporary but now a part of the system network simply because they were built to higher standards than needed and were considered "too good to close."

Finally, none of the transportation plans indicate a deliberate intent to manage some parts of a Forest without permanent roads. Neither do they indicate intent to close any of the system roads to public travel, even temporarily, in the interests of reducing or preventing conflicts in resource use. Decisions to manage some areas without roads, or with only minimum-level temporary roads and prompt closure, are reflected in multiple use plans on some of the Forests. These decisions, however, cannot be readily understood from a review of transportation plans.

SUITABILITY OF ROADS

The claim that most roads are designed only for timber harvest warrants careful consideration. Our conclusion is that many of the roads that serve timber harvest were planned to serve other needs as well. In some instances, however, the design of these roads has rendered them less suitable than they should be for recreational purposes. Attention to functional and structural elements outstripped concern with form and relation to the natural surroundings.

Roads in the Forests have tended to be engineered rather than designed. Selection of the corridor in which roads are located has been based mainly on road construction aspects, such as grade, alignment, and availability of

Table 1. — System and temporary roads, fall 1970, on the Bighorn, Shoshone, Teton, and Bridger National Forests

National Forest	Total system roads	Total temporary roads	System roads built since 1960	Temporary roads built since 1960	Closed temporary roads
	Miles				
Bighorn	260	189	114	160	70
Shoshone	857	169	117	131	93
Teton	386	175	99	123	36
Bridger	919	423	191	308	173
Total	2,422	956	521	722	372

Figure 28. — An excessively wide roadway clearing dominates the landscape and degrades the viewer's experience. (Fish Creek, Teton National Forest)

roadbuilding materials. The relations between travelers and their environment have not been sufficiently investigated, so that some Forest roads are good for vehicles but not good for people. The qualities that determine the esthetic suitability of roads have not been precisely identified or defined.

Much of the criticism directed toward roads apparently constructed for single use could have been avoided by better location and design. Certain roads suggest single use rather than multiple use because they reveal insensitivity to the variations of the landscape.

Some right-of-way clearings are excessively wide for a one- or two-lane road; we observed widths of 100 feet to 200 feet or more. An example on the Fish Creek Sale (fig. 28) is on a gentle side slope, and grading for the cross section demands use of only a fraction of the total cleared width. The narrow road within the dominant opening is obviously detached from its surroundings. The avowed purpose of the wide clearing was to facilitate snowmelt on the road, but public suspicion is understandable that the road clearing is actually an elongated strip clearcut.

Figure 29. — The view from a road through a large clearcut is monotonous and lacks interest. (Sheridan Creek, Shoshone National Forest)

Figure 30. — Here a "pigtail" spur effectively separates the harvest area and a permanent road. (Enos Creek, Shoshone National Forest)

A road built through or alongside a large clearcut also creates an impression of single purpose. A central location is efficient during timber harvest, but it does not recognize the need for pleasing appearance after the harvest. On the Shoshone, a system road is routed through the heart of the 1,200-acre Sheridan Creek clearcut (made in 1953). Travelers on the road are forced to look at the logged area itself since there is nothing close by of greater interest to attract attention (fig. 29). Although slash cleanup is of quite high order, there is an overall impression of carelessness from the light scatter of charred slash, inconspicuous and sparse regeneration, and a ground plane that suggests deteriorated grassland.

Another road location that emphasizes logging is found in parts of the Wiggins Fork system road leading to an entrance to the Stratified Primitive Area. Characteristically, the road is threaded against the edge of certain clearcuts along the route. This has the distinct advantage of intimate linkage with the forest edge on one side as compared to a road that is central in a cut opening. In one place, however, a clearcut of several hundred acres, in which pole slash now visually dominates young reproduction, becomes the foreground against which the perimeter peaks and basin of the Stratified Primitive Area are viewed (see fig. 6). There are encouraging signs of future improvement, but at present the view at the entrance to a wilderness area is much degraded.

A more satisfactory relationship between a system road and a timber cutting exists in the spruce-fir group harvest units off the Enos Creek road, Shoshone National Forest. Rather than running the main road adjacent to the cut block — or hooking the two together with a broad opening — a "pigtail" spur connection is used (fig. 30). This short spur with curve or reverse curve effectively separates the small cut block from the roadway. The multiple purpose aspect of the road is maintained. Although this handling for a small-scale cut block cannot be directly compared with that of the large-scale Wiggins Fork blocks, the road access design is noted as a pattern worthy of more widespread application.

CLOSURE OF TEMPORARY ROADS

As previously indicated, two-thirds of the temporary roads ever built on all of these Forests still had not been closed to vehicular traffic by the fall of 1970. We recognize that it is necessary to leave temporary roads on timber sale areas open until after the logs have been hauled, slash disposed of, and any necessary planting completed. We question the need, however, for leaving such a high percentage of temporary forest roads open to traffic for such long periods of time. This conflicts with Forest Service policy on road closure.

Several Forest Service regional officials explained to us that it was difficult to get the Forests to follow the policy. On the other hand, some Forests reported that persistent recreational use of logging roads was a deterrent to planned closure. Closure problems on these four National Forests are further complicated by the relatively gentle slopes and natural openings that typify the terrain. Where physical closures were installed, it was very often possible simply to circumvent the barriers with a four-wheel-drive vehicle.

Although gentle terrain undoubtedly makes physical closure of roads difficult or impossi-

ble, we believe that any road designated for closure can be and should be closed by posting and policing if no other method seems practical.

RECOMMENDATIONS

- **Transportation plans should indicate the purpose of every proposed road — whether permanent or temporary, the disposition of each temporary road, and the maximum level of road construction needed to attain management objectives.**
- **The transportation plan should be clear and logical, and presented in a form easily understandable to the public, and should specify drainages that will be exempt from any road construction or managed with temporary roads only.**
- **The temporary roads still open should be carefully evaluated; those classified as temporary should be closed and all others reconstructed as required for maintenance as part of the permanent road system.**
- **In road layout and design, the relation between the road and the landscape should be clearly established so as to avoid a result suggesting single use.**

Controlling Environmental Effects of Roads

The possibility of disturbance of the ecological balance in forests increases with use. The balance is extremely delicate in some areas, and failure to recognize the allowable limits of disturbance has led to serious resource management problems. Some forest areas can undergo severe treatment and remain relatively stable. Others deteriorate acutely after only slight disturbance. Road construction is one of the most severe disturbances that man can impose upon forest land. Roads expose raw mineral soil to erosion and alter the contours of the landscape; road access to forest land must inevitably disturb wildlife to some degree. Management practices that minimize the undesirable environmental effects of roads are essential.

WATERSHED

It has been charged that road planning and construction on the Wyoming Forests have been faulty, causing accelerated soil erosion, increased sedimentation in stream channels, and damaged fisheries. Experience and research in a number of places — from the Great Smoky Mountains of North Carolina, the Appalachians of West Virginia, and the White Mountains of New Hampshire through the Rocky Mountains of Arizona, Colorado, Idaho, and Montana to the Sierra Nevada of California and the Cascades of Oregon and Washington — confirm that roads are the main cause of reduced water quality in forested watersheds (Packer 1967). Much of this same research also shows that well-designed roads located away from water courses and provided with proper drainage need not cause damage to the quality of streamflow. We saw evidence that a high degree of quality control can be obtained in road construction. Perhaps the best examples in this respect are the Antelope Mountain and Enos Creek roads on the Teton and Shoshone National Forests, respectively. These roads were designed, located, and built with the greatest regard for watershed and esthetic considerations (fig. 31).

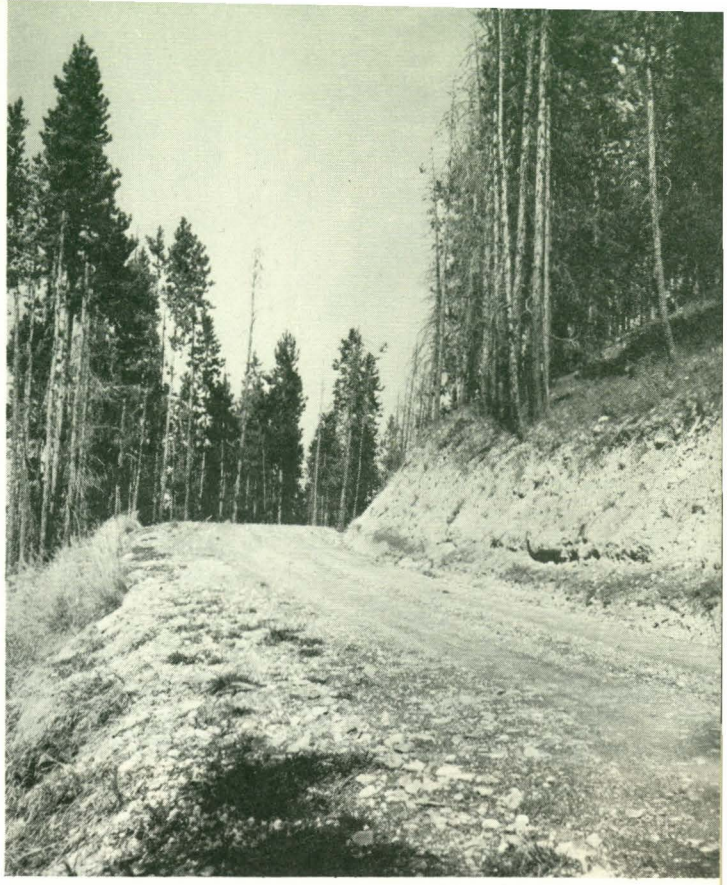


Figure 31. — Road construction here shows high quality control with consideration of esthetic and watershed values. (Antelope Mountain, Teton National Forest)

Figure 32. — Lack of surface drainage has caused rilling on this road. (Gypsum Creek, Bridger National Forest)

Figure 33. — This stretch of road is unduly wide, and surface drainage is inadequate. (Leads Creek, Teton National Forest)

Our observations strongly support research conclusions as to the importance of specific road design and construction criteria. In each of these Forests we encountered unstabilized road cuts and fills, poorly installed culverts, and sections of roads having improperly spaced drainage facilities. Of special importance are the many miles of temporary roads on which soil is being eroded because logging activities continued so far into the fall or winter that surface drainage facilities could not be installed in the frozen earth. These rather frequent occurrences of soil erosion and sediment movement from roads toward streams are reason for serious concern (fig. 32). Damage to watersheds and water quality from these sources has not yet been great, but there is urgent need to develop better quality control in roadbuilding and maintenance.

We did see several instances of road construction on unstable areas, threatening serious watershed damage. A review of the conditions on five of these areas illustrates several problems.

Leads Creek — Part of the main haul road was built through soil derived from glacial silt, which is highly susceptible to accelerated sheet and gully erosion. Excessively wide stretches of this road (fig. 33), coupled with inadequately spaced surface drainage and a few plugged culverts, have allowed sediment-laden runoff from the road to enter Leads Creek in several places (fig. 34).

Three Forks Creek — The upper portion of the main haul road traversed extremely steep slopes. Here again, an excessively wide road was built, resulting in high vertical cut banks that are now collapsing, and overly steep fill slopes that are sloughing away (fig. 35).

Cabin Creek — Portions of the main haul road were built across obviously unstable slopes ("slump topography") and potential landslip areas. As a result one entire section of road, several hundred feet long, has actually slipped down the hill into the drainage bottom, creating a new source of sediment during high-water periods (fig. 36).

Poison Creek — Portions of some of the temporary roads are on locations that do not allow good surface drainage. Overland flow down these road surfaces has concentrated to the point where large rills and small gullies have been eroded in the roadbed (fig. 37). We saw no

Figure 34. — Sediment has been carried from the road into the stream course. (Leads Creek, Teton National Forest)

Figure 35. — Steep fill slopes are sloughing away and high vertical cut banks are collapsing. (Three Forks Creek, Bridger National Forest)

direct evidence that sediment from these eroding surfaces had reached streams yet, but unless adequate surface drainage facilities are installed on these roads, it can be expected to do so eventually.

Brooks Lake (Jules Bowl) — Roads were constructed on relatively stable soils derived from variegated clay stone, shale, and sandstone, and from coarse glacial till. Some of the temporary roads were built at grades of more than 12 percent and some were excessively wide (fig. 38). Many of the fine soil fractions have already washed off these roads, leaving a rocky erosion pavement in places. Some poorly constructed cross-drains have broken through, permitting surface runoff to concentrate sufficiently to wash soil downslope. Fortunately, since most of the roads are far removed from Brooks Lake Creek, there is small probability that sediment will reach this live stream. Part of the Brooks Lake timber sale area is located on slump topography showing mass instability, especially when the soil mantle becomes saturated. In several places large amounts of logging residue, some from road construction, were left in small tributary stream channels, thereby slowing the normal drainage of water out of small basins and permitting the soil mantle to become locally saturated continuously. There

Figure 36. — Landslip in "slump topography" has carried part of a road into the drainage bottom. (Cabin Creek, Bridger National Forest)

is already evidence of increased mass soil slumping as a result of this.

These mistakes in road location and construction are not isolated instances and they are cause for concern for several reasons. First, the knowledge necessary to prevent them was available but not used. Second, they cannot be dismissed on the grounds that "we are no longer doing it this way." Some of the cited roads were built during the past 5 years. There is still not enough quality control of road construction for watershed protection.

RECOMMENDATIONS

- **The quality of design, location, and construction of roads, especially temporary ones, must be greatly improved to avoid unnecessary damage to soil and water.**
- **Existing specifications that temporary roads should be maintained for adequate drainage before winter should be scrupulously observed.**
- **Much greater use should be made of geologists, hydrologists, and soil scientists in planning and constructing roads.**

Figure 37. — Small gullies have formed because drainage from road surface is inadequate. (Poison Creek, Bighorn National Forest)

Figure 38. — A rocky erosion pavement has developed on this excessively wide and steep temporary road. (Brooks Lake, Shoshone National Forest)

WILDLIFE

The effects of roads on big game populations, specifically elk, are almost impossible to evaluate because there is no adequate information. The charge is made that road access makes elk more vulnerable to hunters and leads to year-round harassment by picnic parties, motorcyclists, Sunday drivers, and snowmobiles. As road densities increase, elk retreat from this disturbance until, eventually, there is no escape left. Game biologists all over the Rocky Mountain West have voiced this concern in recent years; as a result some roads have been closed, and a number of timber sales have been modified.

The claim is also made that logging can improve elk habitat. The literature does in fact report some significant improvement from logging, but the conclusions are based on forage production rather than animal behavior studies. The Jackson Hole herd and many other feeding operations can be cited as evidence of elk tolerance for close association with man, but these are unnatural situations.

We tend to agree that timber harvest could create a potential for harassment of elk during rutting and calving, and there is no question that easy access increases vulnerability to hunters. Nevertheless, there are no reports in the literature to demonstrate that roads and logging are necessarily detrimental to elk population levels. A description of elk management problems in the Wind River drainage is given at the end of this section to illustrate how increased access can complicate management decisions.

Although we cannot substantiate damage by roads to the wildlife resources of Wyoming, we believe this problem has very strong implications for management. First, even our brief examination of the northern Wyoming area confirms the value of the wildlife resource. The Jackson Hole elk herd has been world famous for over five decades. Elk harvests in northern Wyoming have averaged more than 11,000 animals annually in recent years. Second, the presence of the two National Parks, Yellowstone and Grand Teton, puts the surrounding National Forests in a unique position. Over a million tourists visit the two Parks each year. The thermal wonders of Yellowstone and the scenery of Grand Teton are major attractions; but the elk, moose, and bear are also extremely significant as a part of the total picture visitors expect to see.

We believe that an overriding consideration of land management on these National Forests should be the health of the elk herds. There is no positive evidence that roads destroy elk habitat, but neither is there proof they do not. Until definitive answers are produced by research, the possible loss of options should be an important consideration in all management decisions concerned with the development of roads. We saw little evidence that past timber management activity has given appropriate consideration to elk herds, but this may not be surprising since the potential conflict has only recently been recognized. There is encouraging indication that present planning does recognize the real value of the resource.

Elk in the Wind River Valley

Elk hunting in the Wind River management unit has been extremely important for many

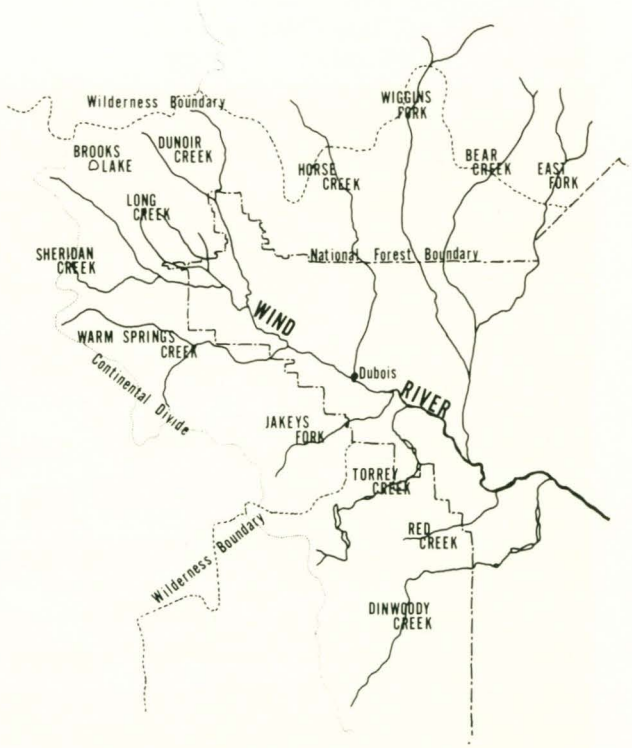


Figure 39. — The Wind River Valley. (Shoshone National Forest)

years. Each fall Dubois, Wyoming, becomes a hub of activity for a 6- to 8-week season in which a thousand or more hunters participate. In Dubois also is a large stud mill run by U. S. Plywood-Champion Corporation. Both activities contribute substantially to the welfare of Dubois, and the basic resources for both activities are derived from the nearby National Forests.

The Wind River Valley resembles a large horseshoe with the toe on the Continental Divide near Brooks Lake and Dubois in the middle (fig. 39). Commercial timber management is confined to a belt 6 to 10 miles wide on the circumference of the horseshoe, and most of the area north of the commercial forest belt is managed as wilderness.

Elk harvest and timber sale records for the Wind River drainage, from 1963 to 1967, are presented in table 2. Analysis of the elk kill demonstrates a significant change in harvest in all but two subdrainages. During the first 2

Table 2. — Wind River elk harvest and timber harvest, by subdrainages, 1963-1967[1]

Subdrainage	Year				
	1963	1964	1965	1966	1967
	Elk killed				
East Fork, Bear Creek	42*–	55	61	111	136
Wiggins Fork, Horse Creek	51	26*–	46	110	118
DuNoir, Long Creek	45	46	42	76	95
Sheridan Creek, Brooks Lake	32*+	28*+	10	14*–	15*–
Warm Springs Creek	26*+	27*+	14	23	23*–
Jakeys Fork, Torrey Creek	13	14*+	2*–	15	11
Red Creek, Dinwoody	5	7	9	21	23
Total, Wind River	214	203	184	370	421

Subdrainage	Year				
	up to 1963	1964	1965	1966	1967
	Acres cut				
East Fork, Bear Creek	—	—	—	—	—
Wiggins Fork, Horse Creek	900	58	103	300	70
DuNoir, Long Creek	—	—	35	—	457
Sheridan Creek, Brooks Lake	478	765	112	472	149
Warm Springs Creek	—	78	368	541	—
Jakeys Fork, Torrey Creek	—	—	—	—	—
Red Creek, Dinwoody	—	—	—	—	—
Total, Wind River	1,378	901	618	1,313	676

[1] *Elk harvest compiled from Dubois Check Station records, Wyoming Game and Fish Department; timber harvest compiled from incomplete records of the Wind River Ranger District, Shoshone National Forest. Statistical data: chi-square = 108.7, 24 degrees of freedom, 0.001 >p. The * indicates cell contribution is 3.5 or more to total chi-square; + or — indicates the direction of deviation from expected values.*

years of record, in the drainages with the heaviest logging activity, Wiggins Fork-Horse Creek produced a substandard harvest while Sheridan Creek-Brooks Lake and Warm Springs Creek were above average. In 1966-67, these latter subdrainages produced a harvest below expectation while Wiggins Fork-Horse Creek showed an increase. Thus, the Wind River elk harvest appears to fluctuate almost without regard to timber sales. As a further complication, total elk harvest had nearly doubled at the end of the 5-year period because the hunting seasons were changed from September 10-October 31 in 1963-65 to October 1-November 15 in 1966-67.

We were told that this change in season dates was instituted to shift the harvest from resident to migratory elk within the Wind River drainage. Elk harvest totals for the area had declined from 362 in 1959 to 214 in 1963 and 184 in 1965. Biologists of the Wyoming Game and Fish Department examined the biweekly distribution of elk harvest. They found that in drainages north of the Wind River, the kill increased in the last half of the season, whereas south of the river a greater proportion of the total harvest was obtained in the early part of the season. From this observation and from tagging studies, Game Department biologists concluded that in the early season there was only a partial harvest of migratory animals coming out of the Teton Wilderness and down DuNoir Creek to winter range on the lower Wiggins Fork. They also believed the resident herd was being overharvested.

Accordingly, the October-November season was initiated in 1966 — and the total number of animals harvested did increase substantially in drainages north of the Wind River. Like many management decisions, however, this one created a whole new series of questions. The 1967 biweekly count still shows over half the harvest taken in the last 2 weeks of the season in drainages north of the river. Moreover, Sheridan Creek-Brooks Lake still shows half the harvest in the first 2 weeks of the season. Does this indicate a still higher potential for harvest in the migratory herd? Or, does it simply indicate the movement of hunters from area to area as snow closes the high country?

There are also unanswered questions about nonmigratory elk. Has the total number of such animals been reduced by increased access and more efficient harvest? Has the harvest thereby been shifted to migratory elk? The data for Wiggins Fork-Horse Creek and Sheridan Creek-Brooks Lake (table 2) tend to support this contention if it is assumed that new roads will lead to an overharvest followed by a drop in the kill. Warm Springs Creek, on the other hand, produced the same pattern — but the high harvest came before logging started.

Thus, there is just enough information available to tantalize us. The correlations are suggestive but not statistically sound. The conclusion that the resident elk herd was reduced is balanced by evidence that a management decision actually produced an overall increase in the harvest. And, unfortunately, the decisions which must be made still depend on unsupported logic rather than scientific fact.

RECOMMENDATIONS

- **The Forests and Regions should actively encourage cooperative research to determine the impact of road systems on elk populations.**
- **The Forest Service should carefully consider a slowdown in construction of new permanent roads until information is available concerning the effects of roads on elk.**

LANDSCAPE QUALITY

Public concern about the visual effects of forest management practices was primarily directed toward clearcutting, but roads were a close second in importance. We observed some road design of commendable quality, yet in some timber sale areas we found design, location, and construction of roads that expressed insensitivity to forest resources other than timber.

Relation of Roads to Landform

Road location is of critical importance because of the powerful capacity of a road to focus attention ahead, forming a "visual corridor" for the traveler. The Antelope Mountain road, Teton National Forest, was constructed basically for insect control and sanitation-salvage cutting, but it was designed with such good relationship to its surroundings that it is now also a scenic road of high quality. For

example, one straight stretch is directed so that the Grand Teton Range is incorporated as a directly linked outview (fig. 40). Conversely, a straight piece of road can make more conspicuous a timber harvest pattern planned without recognition of landscape impact. The Owens Creek cuttings on the Bighorn Forest (see fig. 4) are conspicuous for the way they modify the appearance of nearby landforms. Had there been appreciation that a road also defines a visual corridor, more careful consideration could have been given and a better effect achieved.

A road can be conceived of as a physical-visual experience in a three-dimensional landscape. On the Antelope Mountain road, a

Figure 40. — A straight road segment focuses the view on Grand Teton Range. (Antelope Mountain, Teton National Forest)

Figure 41. — Road curvature is sensitively adjusted here to conform to the terrain. (Antelope Mountain, Teton National Forest)

Figure 42. — Two road design flaws are shown here: the straight portion between two curves is poorly fitted to landform and cleanup is imperfect. (Brooks Lake, Shoshone National Forest)

Figure 43. — The relation of road to wolf tree and corral shows sensitivity to detail. (Antelope Mountain, Teton National Forest)

curved segment is laid out so that it is complementary to a concave terrain form (fig. 41). Here the road conforms to the landscape and is subordinate to it. Quality suffers, however, if the relation of road to landform is unsatisfactory. On the Brooks Lake road, Shoshone Forest (fig. 42), the straight portion of the road between two curves cuts through a rounded spur ridge. Straight road and convex land surface do not match, and a visual break results. A curve of longer radius could have conformed directly to surface form, also maintaining visual continuity of the roadway. Other negative aspects of this road include an overly wide and uniform clearing line on the high side, windthrow, and incomplete slash cleanup. The positive aspects are the display of the stratified peak feature and the clearing variations tied to minor openings on the lower side. The visual quality of this road segment is mediocre, but additional attention to design and construction could have produced superior quality. Unqualified concern for the visual environment could have prevailed, but it did not.

The detailed adjustment of road layout to recognize local landscape variations and features is a way to integrate the road to its immediate surroundings. We observed both care and carelessness in this regard. Carelessness was most evident in roads alongside clearcuts or inside them (see figs. 1, 6). There is need for concurrent planning of roads and harvest layout. Care, in the form of sensitivity for small things, is shown in fig. 43 as the Antelope Mountain road passes close by a wolf tree and adjacent fence. This simple design linkage to an isolated tree and a human artifact suggests what can be done. We are convinced, however, that it cannot be generally accomplished without special bolstering and training of staffs. More flexible road design standards are needed, including standards for roads of smaller scale.

Cuts and fills indicate the degree to which the horizontal and vertical layout of the road fits the landscape. They are not undesirable as long as they are minimal and the road does not seem to disrupt the flow of land surface (fig. 44). Roads on the four Forests cannot be seri-

Figure 44. — The visual flow of land surface is maintained here through minimum cuts and fills and careful planning of road location. (Antelope Mountain, Teton National Forest)

ously criticized for excessive cuts or fills — largely because much of the roadbuilding is on gentle topography. More could be done, however, to modify cuts and fills through slope flattening and planting, for both erosion control and visual continuity with natural surroundings. Not enough is being done to finish up road construction with revegetated side slopes.

We envision that the design of all system roads in these four Forests will recognize that the quality of experience derived from road-based travel depends upon sensitive treatment of the relationships between road and landscape. The technical staff must be available and have the expertise to do this. We have commented elsewhere on the need for special staffing and training.

RECOMMENDATIONS

- **Road location and design should be better coordinated with the landscape than they are at present:**
  - **Planning and road design should routinely include thorough exploration of visual alternatives.**
  - **The visual corridors created by both existing and proposed highways and perma nent forest roads should be recognized as requiring special attention.**
  - **More flexible road design standards, encouraging small-scale roads where they are appropriate, should be adopted.**

Logging Residue

The harvest of trees, like the harvest of other crops, leaves an unused residue, consisting mainly of foliage, limbs, treetops, roots, and stumps. Trees or portions of trees that are too defective, too small, too crooked, or of too low quality for any present practical use are also left on the ground. The volume of residual material depends primarily on the condition of the timber stand, the harvesting method, road right-of-way clearing, and the market demand for wood products.

Much of the criticism of timber harvest practices on the four Forests can be attributed to the inadequate, improper, or poorly timed treatment of logging residue. Unsightliness was most frequently mentioned. In addition there were frequent complaints about waste of apparently usable material, creation of barriers impassable to wildlife, air and water pollution, soil disturbance resulting from treatment, and excessive treatment costs. A substantial number of people also expressed concern about inconsistencies in residue treatment methods used on different Forests.

We observed on the ground the results of practices ranging from virtually total disposal of the residue (fig. 45) to no treatment whatever (fig. 46). We also found considerable variation in treatment methods, standards, and performance among the Forests and between the Regions. Each of the Forests has a backlog of unfinished treatment work to do.

The treatment of residue may include any one or, more often, a combination of such actions as burning, scattering, burying, piling, or crushing (rolling). Silviculturally, residue is treated to reduce fire hazard, help regenerate a new stand of trees, and, for some tree species, reduce insect hazard to the remaining trees. On many sites, residual woody material is needed to provide a microclimate favorable to the survival of tree seedlings, and to help protect soil from erosion. Other considerations are protection of scenic quality, prevention of mechanical obstruction to the movement of people and animals, and protection of air and water quality.

Several treatment methods have been or are now being used. No treatment — an alternative in which the residue is left untouched after the merchantable wood is removed — has been

Figure 45. — Disposal of logging residue is virtually total here. (Curtis Canyon, Teton National Forest)

Figure 46. — Logging residue here has been left untreated. (Union Pass, Shoshone National Forest)

Figure 47. — Residue on this clearcut has been broadcast burned. (Wiggins Fork, Shoshone National Forest.)

Figure 48. — Residue here has been pushed by by tractor into linear windrows in preparation for burning. (Little Beaver, Bridger National Forest)

Figure 49. — Residue here has been piled for burning. (Little Flat Top, Bridger National Forest)

practiced with results such as those shown in figure 46.

Broadcast burning, now discontinued on the four Forests, consists of burning the residue where it falls without further handling. In practice, a fireline is constructed around a body of slash, and the area is then progressively fired in predetermined spots and directions in such a manner that the area burns essentially all at the same time. Use of this method requires a sufficient volume of woody material to carry the fire and create sufficient heat to achieve desired levels of removal. Broadcast burning is usually confined to areas harvested by clearcutting (fig. 47).

The **windrow and burn** method utilizes tractors with brush blades to push residue into windrows preparatory to burning (fig. 48). Tractors usually work downhill, bunching the residue into continuous windrows at right angles to the slope, where it is burned. The method is usually restricted to areas harvested by clearcutting.

In the **pile and burn** method, the same kind of equipment is used except that the residue is pushed into piles rather than windrows before burning (fig. 49). This technique has more flexibility than the windrow and burn method and can be used following harvest by partial cutting as well as by clearcutting.

The **roller-chopper** method utilizes a large, heavy, ribbed metal drum, drawn by a tractor as shown in figure 50, to break and mash residue down onto the ground where it will decompose more rapidly. The drum is usually 8 feet or more long and 4 or 5 feet in diameter with square or diagonal cutting flanges welded to the exterior surface. The drum is hollow, but filled with some liquid for weight while working. The equipment is usable only on level or gently sloping ground and is fully effective only in areas of light concentrations of small-diameter residues (fig. 51). Larger logs and stumps reduce the efficiency of the method. Because of the size of the equipment, efficiency is low except on relatively large areas. Where patches of very heavy concentrations of residue ("jackpots") have accumulated, the material is often bunched into piles and burned.

The **lop and scatter** method employs manual labor using axes or power saws or both. Limbs

Figure 50. — This large metal drum, drawn by a tractor, rolls and mashes down residue, chopping small-diameter material.

Figure 51. — Residue was roller chopped here in 1969 on gentle terrain after harvest in 1968. Advanced regeneration is now showing. (Caribou Mesa, Bighorn National Forest)

are cut from felled trees and scattered on the ground to decompose by natural means. The method does not provide for adequate fire hazard reduction if residue volumes are large, and firebreaks are often installed at strategic locations to minimize the danger of fire spread. Also, as in the roller-chopper method, "jackpot" concentrations are usually bunched and burned.

Residue Treatment on the Forests

An analysis of the effectiveness of past methods of treating logging residue reveals several deficiencies. There has been unwarranted optimism that successful regeneration would be achieved without proper residue treatment as indicated by timber stand conditions, including seed supply. This optimism stemmed partly from lack of adequate factual information, and partly from reliance on experience gained in other locations not really comparable to Wyoming. There is much evidence, too, that planned treatments were not accomplished on schedule or as intended. In some instances, shortage of manpower and money led to delays in treatment. Generally, administrators did not anticipate the strong public reaction to the unsightliness of untreated residues on logged areas. Whatever the reasons, there is much more untreated residue on the four Forests than sound timber management practices would dictate.

Many of the inadequacies and problems of logging residue management are now recognized. Significant changes have been made in an effort to avoid repetition of past errors. On the Bridger and Teton Forests, for example, current practice on clearcuts is to machine pile and burn the logging residue. Sale contracts on these Forests of Region 4 require that all slash from trees cut before August 15 be piled for burning by November 1. Burning is done no later than the following year. The appearance of harvested areas after these treatments is usually good. In a few of the areas where piling and burning were done, however, we question if enough of the residue remains to encourage regeneration and protect the soil. For selection or shelterwood cuttings, limbs are lopped and scattered and, where needed, concentrations of residue are piled and burned. Shortcomings common to the lop and scatter treatment are the lack of a desirable mineral seedbed (see the section "Regeneration"), and the disorderly appearance of the area.

On the Bighorn and Shoshone Forests of Region 2, treatment of logging residue reflects a variety of past and current policies. On selective and shelterwood harvest areas, residue is lopped and scattered. The inadequacies associated with this treatment are the same as noted above. On clearcuts, burning has been discontinued except for "jackpot" concentrations, and the logging residue is roller-chopped after one season of drying. Except on uncompleted sales, the Wind River District of the Shoshone no longer has stands suitable for clearcutting. The lop and scatter treatment is commonly used on the small cutting units. These, together with the areas awaiting roller-chopper treat-

ment, tend to give a general appearance of disorder.

People we talked to on Region 2 Forests generally praised the roller-chopper method, primarily on the basis that the chopped residue reduces soil moisture losses and provides shade for tree seedlings. There have been some successful results; for example, on parts of the Caribou Mesa sale (see fig. 51) young trees are numerous after this roller-chopping. But the technique is effective only on slopes of about 25 percent or less. From the available evidence, it does not seem to solve all the problems posed by logging residue.

Current objectives for managing the residue are major steps in the right direction, but we can give them only qualified endorsement. There are still some unanswered questions about current practices that require further study. For the most part, foresters are aware of the alternatives available and the reasons why timing, method, and proper followup action are needed. The treatment should be much more carefully chosen to fit the varied site and timber stand conditions before the timber harvest. Some available knowledge is not being used, and additional research and testing in the field are undoubtedly needed. Also, the backlog of untreated logging and road-clearing wood residues that exists on each of the Forests should be scheduled for treatment.

A problem that has aroused public comment is the apparently high volume of waste material on cutover areas on the Forests. Most of the harvest is in the lodgepole pine type, and yields and product values are relatively low. There was little management except for fire protection until recent years. Selective logging for railroad ties removed only the better trees. Thus, many stands now contain large quantities of poor quality wood.

Timber harvesting would be more acceptable to many critics, and logging residue management would be simplified, if more of the wood was removed and converted to useful products. Progress in reducing the residue would result in less waste, lessen the potential for air pollution from burning, reduce the possibility of stream pollution, and improve the esthetic effect of timber harvest. The cost of removing and processing more of the material may now be too high to attract buyers, but this phase of timber management practice deserves strong and continuing emphasis by the Forest Service and the timber industry.

The inconsistency between Forests in treatment of residue has drawn some public attention. Sound practice may require deviations from standards or guidelines to fulfill the requirements of a specific silvicultural prescription. On the other hand, from our observations it is hard to understand why one treatment method should be considered the only viable technique on the Teton Forest, whereas the Shoshone uses another. We believe training and written guidelines for residue treatment are currently inadequate, and that both need attention at Regional and Forest levels. Allowance should also be made for flexibility in the use of guidelines.

Controlling Environmental Effects of Residue

The possible adverse effects of logging, as specifically related to logging residue and its treatment, have aroused concern for air and water quality, soil stability, and wildlife habitat, as well as scenic quality. No studies concerning these matters, specific to these four Forests, have been made, but some broad conclusions are possible from observation and information from other areas.

AIR AND WATER QUALITY

Our observations suggest that potential for air and water pollution on the four Forests is relatively low. As noted earlier, except for road right-of-way slash and some "jackpot" concentrations, logging residue is not burned on the Bighorn and Shoshone Forests. The Teton and Bridger Forests pile and burn on clearcut units. When residue is piled, options for time of burning are extended. It can be accomplished during periods when atmospheric conditions are favorable for dispersal of smoke. We did learn that burning is sometimes done when weather conditions may not be favorable. To avoid distraction and disturbance of tourists, the Teton Forest schedules burning for late fall when most of the tourists are gone. Beaufait's (1968) studies in Montana suggest that this may be a poor time of the year for such activity because of increased atmospheric stability. Temperature inversions are a common phenomenon of fall

Figure 52. — This wall of windrowed slash could be a barrier to big game movement if allowed to remain. (Kinney Creek, Bridger National Forest)

weather, and the probability of smoke collecting in the valleys is very high.

The question of whether decomposition of logging residue could contribute nutrients that become a source of chemical pollution in forest waters has been investigated on the Hubbard Brook Experimental Forest in New Hampshire (Likens et al. 1970). This research indicated marked increase in dissolved nutrients after clearcutting. The Federal Water Quality Administration's "Industrial Waste Guide — Logging Practices" (1970) identifies logging waste as a chemical pollution source in the Pacific Northwest.

The applicability of these data is not entirely clear, since our observations in Wyoming did not include collection of nutrient data in streams. The Hubbard Brook study was not identical with a timber harvest activity. None of the logged material was removed or burned, and all living plants on the site were killed, thus preventing natural uptake of nutrients from decomposing material. In the Northwest, a much larger volume of logging residue is commonly present to contribute dissolved nutrients. Considering the smaller amount of residue and the generally heavy growth of forbs and grasses on Wyoming clearcuts, pollution by chemical nutrients does not appear to be a significant threat. Research to determine the true magnitude of this problem is needed.

SOIL STABILITY

Logging residue treatment may or may not increase the soil erosion hazard, depending on the method used, and where and how it is applied. In our examinations of many sale areas we found little evidence of increased erosion resulting from logging residue treatments. The lop and scatter method used when partial cuts are made leaves all of the woody material as a protective cover on essentially undisturbed soil. The roller-chopper method, sometimes used on clearcuts, leaves all of the residue on or near the ground surface and causes only minor soil disturbance. Piling and burning disturbs far more of the soil, but when properly done leaves an adequate protective cover of small woody material and duff on or near the soil surface.

In a few instances we observed excessive removal of protective ground cover and unnecessary disturbance of soil as a result of bulldozer piling of logging residue, not only on gentle terrain, but also on slopes in excess of 35 percent.

Figure 53. — Natural conditions in some stands appear to create barriers to big game movement. (Bird Creek, Bridger National Forest)

These operations have undoubtedly created a potential for erosion and sediment production. We believe that logging residue disposal by bulldozer piling can and should be done in a manner that prevents baring of excessive amounts of soil. It should be limited to slopes of less than 35 percent.

WILDLIFE HABITAT

The public fear that logging residues can create barriers to the movement of big game is easy to understand. Walls of windrowed slash, as shown in fig. 52, could inhibit elk and deer movement. It is quite likely such a wall will persist a long time, but we saw only a few. We believe the creation of potential barriers should be avoided, but we also believe the degree of concern is out of proportion to the actual problem in Wyoming. The windrowed slash on clearcuts and road right-of-way clearings may present significant potential problems, but all of the Forests are making good progress in solving them. We also believe untreated slash is not likely to create barriers. After all, there are many lodgepole pine "jungles" (fig. 53) that are not much different from untreated logging slash; these seem to pose no barrier, as any elk hunter can testify.

SCENIC QUALITY

A disturbing visual effect is created by untreated logging residue, seen either alongside roads or trails, or in the cutting units from adjacent travel routes. This was observable in July 1970 along the road south of Fish Creek on the Teton Forest, where cutting had taken place in 1969. A wide right-of-way clearing connected a series of cut blocks, the combination producing the visual image of an excessively large timber harvest. Until cleanup is accomplished, that impression will reflect adversely upon management.

Logging is a "crude" operation in the visual chaos it creates. The standard practice is to delay residue treatment until after the merchantable material is removed. Although the condition may be temporary, when viewed at this stage by a casual visitor it often leaves a

Figure 54. — Although residue cleanup is good here, it is inadequate for the critical roadside zone. (Flagstaff Road, Teton National Forest)

lasting unfavorable impression. Both windrowing and piling, as intermediate steps before burning, at least give an orderly appearance. Such steps are visual clues that management is coping with the problem.

The practical importance of immediate treatment may be open to question, but the visual problem should be recognized and dealt with accordingly. Roads and trails might be closed until treatment is complete. If closure is not feasible, signs might inform the public that rehabilitation measures will follow.

The prompt and complete cleanup and disposal of road right-of-way slash is especially important. At a roadside, even a small amount of partially burned slash must be considered detrimental as seen by the forest visitor (fig. 54). Roadsides are, in effect, display areas demanding the most complete treatment. The practice of accomplishing cleanup concurrently with road construction is good. The Bridger and Shoshone Forests, on the Mosquito Lake and Enos Creek roads, respectively, have done this job well.

RECOMMENDATIONS

- **Forest Service Research, National Forest Administration, and the timber industry should jointly explore possibilities for using more of the wood left after logging, and for treating the remaining residue to facilitate natural and artificial regeneration and reduce the unfavorable visual impact.**
- **The Forest Service should establish exploratory studies to determine the effects of logging residue management on water quality.**
- **The Forests should secure timely meteorological information, and require that logging residues be burned during periods when burning is least likely to affect air quality adversely.**
- **The Forests should do a complete job of treating right-of-way clearing residues concurrent with construction of all roads open to public travel.**
- **The Forests should eliminate the backlog of untreated residue as soon as possible.**

Regeneration

The critical importance of prompt regeneration to successful silviculture has been pointed out in earlier discussion. In Wyoming, this phase of management has become a focus of contention; many people do not believe a new tree crop is being established following clearcutting. We were told that the Forest Service does not have the technology to accomplish regeneration in Wyoming's harsh climate, and we were shown cutting after cutting in which no small trees were visible from the road.

The important Wyoming timber species do have individual requirements for regeneration. These must be understood before the results of efforts to establish new forests can be properly evaluated.

Regeneration in Lodgepole Pine

Successful natural regeneration of lodgepole pine depends upon three factors: (1) a good supply of viable seed widely dispersed over the cut area, (2) favorable seedbeds for germination and seedling survival, and (3) suitable moisture and temperature for seedling growth. Unless these conditions are met, natural reproduction may fail or may not become established for a long time.

SEED PRODUCTION AND DISPERSAL

The importance of cone serotiny — the closed cone habit — to regeneration of lodgepole pine has been described with reference to silvicultural prescriptions (see p. 13). Over much of its range, lodgepole pine produces predominantly serotinous cones, which hang in the tree crown, tightly closed, for years, thus preserving large quantities of viable seed. Recent studies show, however, that trees on extensive areas of the Teton, Bridger, Shoshone, and Bighorn National Forests are predominantly of the nonserotinous, or open-cone, habit. Seed is shed and disseminated by wind annually on these areas, so that little or no seed is stored in the crowns.

Where the cone habit is primarily serotinous, seed dissemination does not occur until heat breaks the resin seal that keeps the cones closed. On clearcuttings, cone-bearing slash scattered over the cut area distributes the seed very effectively, provided the cones are brought close enough to the ground to receive the radiated or convective heat needed to open them (Crossley 1956). A temperature of 113° F. is needed to break the resin seal. Cones within about 1 foot or less of the ground usually open and release most of their seed during the first summer season. Consequently, in stands with serotinous cones, seed dissemination does not restrict the size of the clearcutting.

The cone serotiny habit varies with elevation, habitat type, and stand history. In western Wyoming, at about 7,000 feet, serotiny and wildfire are common in the Douglas-fir/pinegrass habitat, but they are less so at 9,000 feet in the subalpine fir — Engelmann spruce/dwarf huckleberry habitat.

Stands that have predominantly open or nonserotinous cones cannot be regenerated naturally in large clearcuts. Seed disseminated by the wind in these stands is dispersed only about 200 feet into the openings. Therefore, strips wider than about 400 to 600 feet are not likely to receive sufficient seed to restock the entire cut. Prompt tree planting is indicated on those parts of the cuttings that are too remote from the seed source to be restocked naturally.

SEEDBED REQUIREMENTS

In most habitat types, lodgepole pine, like many other species, requires a well-prepared mineral soil seedbed for best seed germination and seedling survival. About 90 percent of the total reproduction is established in the first 2 years. Although some germinants appear in ensuing years, they usually balance the losses rather than increase the stocking.

Exposure of mineral soil and removal of competing vegetation provide the best seedbed for both germination and seedling survival. On exposed soils the roots of lodgepole pine seedlings penetrate to a more stable supply of soil moisture than is found in the organic surface material of the natural forest floor.

Regeneration in Spruce-Fir

In establishing Engelmann spruce in cutover areas, adequate site preparation and attention

to quality, care, and handling of planting stock are the keys to success. Apparently, a determining element is the ecology of spruce and fir as they grow together to form high-elevation forests.

Mature Engelmann spruce, in association with subalpine fir, forms a relatively stable forest vegetation. The stands are not easily displaced by other vegetation, except when disturbed by logging, fire, or insect and disease attack. Complete removal of the stand by such disturbances results in drastic environmental changes that tend to favor establishment of species less tolerant to shade, such as aspen and lodgepole pine. Under natural conditions spruce becomes readily established only on mineral soil and rotten wood seedbeds, whereas fir is not exacting in its seedbed requirements. Furthermore, although spruce seedling survival is better in the shade than in the open, spruce cannot compete with fir under the low light intensities commonly associated with dense spruce-fir forests. Once established, however, spruce lives longer than fir (Alexander 1958).

Spruce seed is light and may disperse in adequate numbers as far as 600 feet from the timber edge. But even great quantities of seed will not stock a cut area in a harsh or incompatible environment. Drought and frost seriously jeopardize the establishment of seedlings after clearcutting. Perhaps the most drastic environmental change caused by the cutting is the increase in solar light intensity at the soil-air interface. Ronco (1970) has shown that high light intensities, typical at upper elevations, contribute to the high mortality of open-grown seedlings. He suggests that solarization — a phenomenon by which high light intensity inhibits photosynthesis — leads to irreversible tissue damage and subsequent death of open-grown seedlings.

High temperatures associated with high light intensity heat the soil surface, thereby increasing transpiration and evaporation. The increased water loss from both seedlings and soil, along with heat-caused lesions on seedling stems, combine to cause considerable additional mortality (Roe et al. 1970).

Many spruce-fir forests have an understory of advanced growth which, if protected from damage during removal of the overstory, may develop into a new stand. Advanced reproduction usually varies widely in age, composition, quality, and quantity, and its potential for further management must be carefully evaluated. Criteria for such evaluation and management guidelines for reproduction following cutting have been developed by Roe et al. (1970).

Regeneration Practices on the Forests

On all four Forests we inspected cutting after cutting in which a cursory observation would suggest no regeneration. Our close examination revealed, however, that many of these "regeneration failures" did indeed have adequate stocking of seedlings — although the trees will not become readily visible from roads or trails for another 1 to 5 years. Nevertheless, the frequency of cuttings that must be rated unsatisfactory is considerably higher than it should be. The practices that have led to this condition need to be carefully evaluated.

NATURAL REGENERATION OF LODGEPOLE PINE

Regeneration plans usually called for planting if natural seeding failed. As a rule not only the natural seeding, but also many of the subsequent plantings did fail. Some, if not most, of the failures were predictable.

Earlier corrective measures could have been taken if the silvicultural requirements for regeneration (cone serotiny and frequency of good seed years) had been properly evaluated. Failure to recognize scarcity of serotinous cones was most damaging. Natural regeneration is bound to fail (fig. 55) in a large clearcut where the supply of serotinous cones is inadequate.

Natural regeneration is easiest in small or narrow clearcuts. In stands with nonserotinous cones, clearcuts should be designed so that seed dispersal from border trees is adequate over the entire clearcut area (fig. 56). Decisions as to the size of such clearcuts, therefore, should take into account the commonly accepted 200-foot dispersal distance of lodgepole pine seed and the quality of seed trees along the cutting margin. The latter requirement, often overlooked, is essential to satisfactory natural regeneration.

Spotty coordination of regeneration factors has sometimes led to failure. Seed dispersal dis-

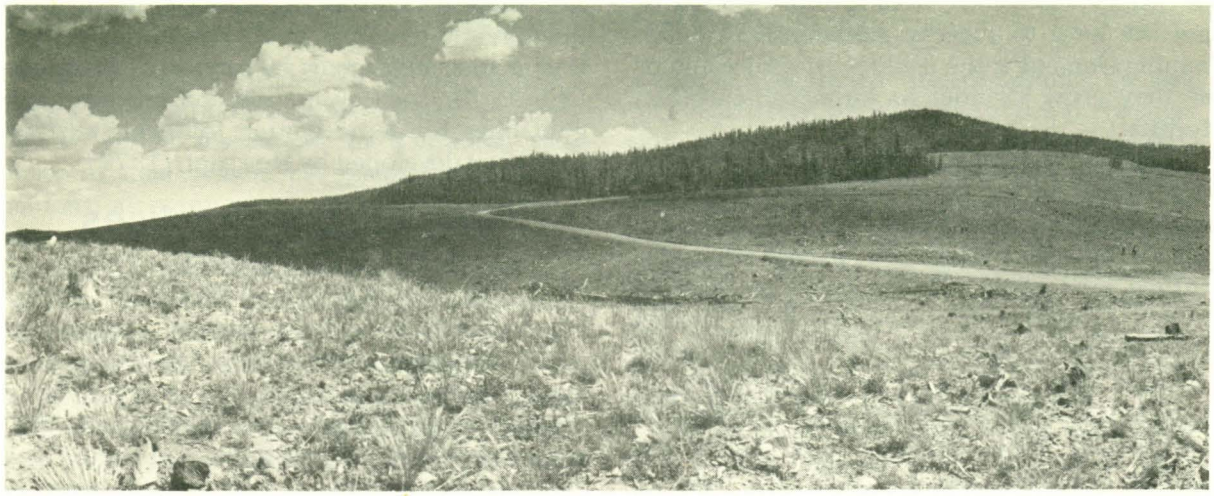


Figure 55. — Lodgepole pine was harvested from this 1,200-acre clearcut 17 years ago. Cones were nonserotinous, and natural regeneration occurred only near the perimeter of the cutting. The area has been planted four times with only marginal success. (Sheridan Creek, Shoshone National Forest)

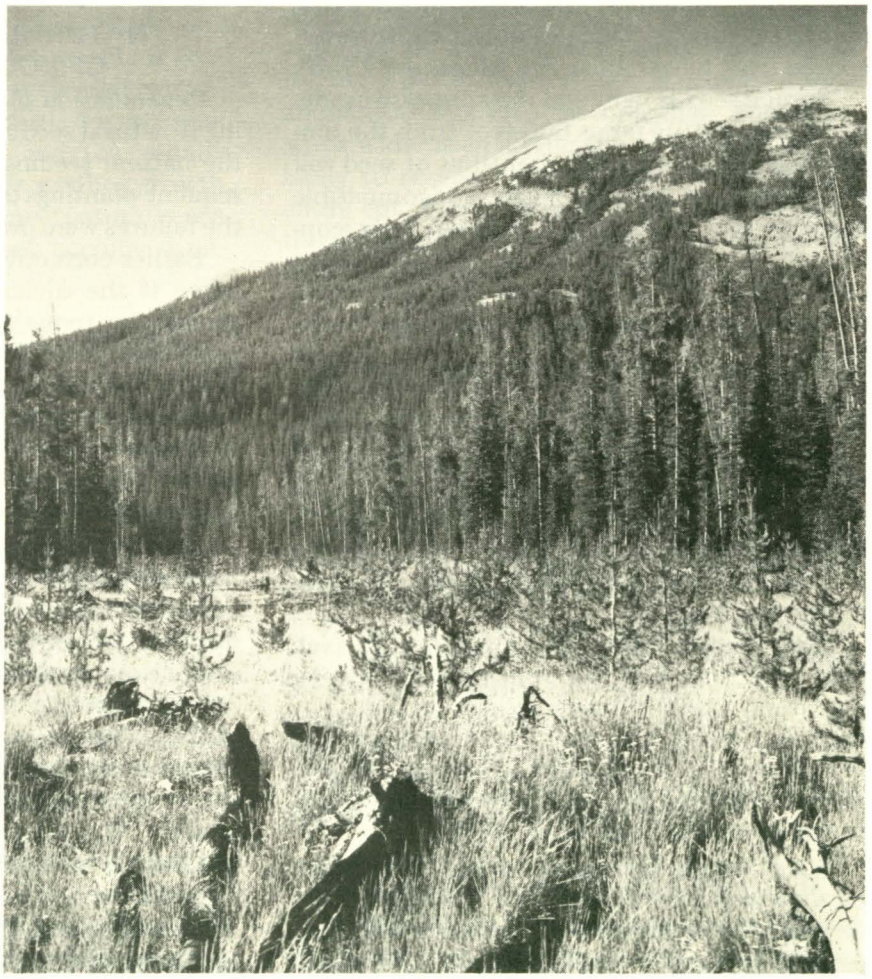


Figure 56. — Natural regeneration is abundant on this narrow clearcut in lodgepole pine. (Bare Mountain, Bridger National Forest)

tance, preparation of seedbeds, and timing of harvest with a good seed crop form a chain of events culminating in a new stand of trees. We observed clearcuts where these requirements were met, but we suspect that such coordination is frequently accidental. The timing of harvesting with good seed years and the scheduling of seedbed preparation following logging are administrative activities easily controlled by man. Sampling techniques are available for estimating the total number of serotinous cones in a stand (Lotan 1963). The status of the cone crop of the stand can be determined before harvest by observing cone development and by seed trapping. Seeding experiments on each clearcut immediately after harvest can give early indications of problems of seed germination and seedling establishment. Close attention to all these factors entails considerable work, but may eliminate the need for costly subsequent site preparation and one or more repair plantings.

ARTIFICIAL REGENERATION OF LODGEPOLE PINE

Tree planting needs to be more than an afterthought. The present practice of supplementing natural regeneration from 3 to 5 years or longer after harvesting creates problems. Too often the site is occupied by other vegetation by the time natural regeneration failures are recognized. Planting then entails the added cost of preparing the site again for good results.

We viewed a potential regeneration failure on a recently completed lodgepole pine clearcut in the Fish Creek area (fig. 57). The area, referred to as the "potato field" because of a nearly complete cleanup of logging residue, was in excellent condition for tree planting. When we saw the tract, direct seeding was being tested and there was some germination of seed spots. The reluctance to plant trees at the same time as seeding was puzzling. The plan for direct seeding showed that the inadequacy of natural seed on the area was recognized. Waiting to see if seed-spot planting would adequately supplement natural regeneration seemed to us to risk loss of a favorable tree planting site to competing vegetation. This sample illustrates the obviously strong efforts to solve regeneration problems, but also points out how critical each step is in attaining regeneration. Seed-spot planting, the weak link in the chain here, would have been best employed as an exploratory trial included in plans for planting the area.

Figure 57. — Residue was piled and burned on this clearcut. The resulting "potato field" was to be seed-spotted rather than planted. (Fish Creek, Teton National Forest)

Mortality of lodgepole pine seedlings was high in some of the plantations we examined. Many of the live seedlings were poor in vigor. Causes included (1) a poor planting area, in which invading plants were well established and competing with the tree seedlings; (2) poor planting methods, such as digging shallow holes, which encourage doubled-over roots; (3) poor selection of spots to plant each seedling; (4) grazing or trampling by livestock or wildlife; and (5) allowing seedlings to break dormancy before being lifted and shipped from the nursery. In the last instance, the new shoots died and the future of the trees was often in doubt. Helpful measures would be to schedule the spring planting immediately after site preparation to avoid losing the site to other vegetation, and to supervise the planting more closely to avoid mistakes. Better coordination of the lifting of stock in the nursery and preparation of planting sites would also bring improvement. Provision could be made for conditioning at nurseries and cold storage facilities as necessary.

SPRUCE-FIR REGENERATION

In general, spruce-fir regeneration on the four Forests still appears to be a trial-and-error operation. The most important first step has been taken, however — a shift from large clearcuts to small openings. The timber management and silviculture staff of each Forest should now make a concerted effort to become familiar with data already available on the biological requirements for seed production, germination, and establishment of Engelmann spruce and subalpine fir. A monitoring program such as that we have suggested for lodgepole pine should then be carried out with the help of research personnel. Efforts to classify habitat type in the spruce-fir forest zone should be intensified and the information made available and applied in forest management.

GRAZING DAMAGE TO REGENERATION

Cattle were grazing in many of the tree plantations we observed. Forest Service personnel showed us that cattle were inflicting some damage on planted trees by browsing and trampling. In varying degree, this kind of damage occurs throughout each of the Forests and is cumulative over a period of years until the trees have grown out of danger. In places the damage eventually reduces survival to the point of plantation failure.

Clearcuts usually revegetate quickly with grasses, herbs, and shrubs, and consequently are attractive to grazing animals. Opinion varies throughout the four Forests as to the seriousness of the grazing problem. In some plantations, cattle are being excluded for a period of years. In others, it seems to us, grazing is almost encouraged. Grazing damage may be easily overlooked, but by examining individual trees we found sufficient evidence to confirm that it was significant. There is a need for more effective protection of regeneration from livestock grazing.

LOGGING RESIDUE TREATMENT AND REGENERATION

Logging residue can be both beneficial and detrimental to regeneration on a clearcut. The method of treatment is often critical in obtaining natural regeneration. Broadcast burning, a useful silvicultural tool in many situations, may destroy the seed in the slash and also damage any advanced reproduction that could otherwise contribute to restocking the area. If delayed too long, treatment by any method often destroys established seedlings.

Some of the merits and limitations of roller-chopping have been pointed out. On the 92-acre Caribou Mesa Sale on the Buffalo District of the Bighorn National Forest, natural regeneration of lodgepole pine following roller-chopping was spotty. Within 200 to 300 feet of the timber edge, the normal dissemination distance for nonserotinous cones, natural regeneration was satisfactory (see fig. 51). At greater distances from the timber edge it ranged from spotty to inadequate, indicating that nonserotinous cones predominated.

A trial of the roller-chopper on the Shale Creek Sale on the Bridger National Forest resulted in good natural regeneration over the entire unit, one having an apparently adequate natural seed source. On the limited basis of these two observations, we concluded that use of the roller-chopper improves the opportunities for natural regeneration when the area re-

ceives adequate seed. Advanced regeneration 1 to 2 feet tall was not usually destroyed. These trees, if not cut by the blades on the roller, would spring back to normal position.

We found that regeneration following the piling and burning technique used on the Teton and Bridger National Forests also was spotty. It appears that planting must always supplement natural regeneration to get the area fully stocked. Although the complete cleanup on recent clearcuts on these two National Forests does give the appearance that a workmanlike job is being done, we feel that it may be somewhat overdone — the first-year barrenness is uncomfortably obvious. This is not a criticism of the Forest personnel who have worked diligently to incorporate this degree of refinement in their timber sale operation, but rather a reflection on the state of the art of regenerating in lodgepole pine stands — how much cleanup is enough?

Given the wide range in results from success to complete failure, the need for considerably more research in regeneration is obvious. Logging residue has a marked impact on the success or failure of regeneration. A method somewhere between the complete cleanup accomplished on the Teton and Bridger National Forests and roller-chopping of slash done on the Bighorn might come closer than either to meeting regeneration needs. In general, the volume of residue left after the merchantable timber has been removed is the critical factor. Finding uses for more of the now unmerchantable wood will help. In addition, more of the residual material should be scattered to avoid concentrations. Then, the roller-chopper might be sufficient to prepare the site for both natural and artificial regeneration.

RECOMMENDATIONS

- **The silvicultural prescription for each stand should include surveys to determine degree of serotiny in the stand, and monitoring to forecast occurrence of seed crops and to estimate seed production.**

- **A regeneration check list should be developed for each proposed timber sale, outlining (a) the sequence of events affecting regeneration, and (b) the treatments needed to obtain satisfactory regeneration, including backup treatments to compensate for failure of any one step.**

PART III

People Are Concerned About the Quality of Forest Stewardship

The issues discussed so far in this report may be summed up in the concern that the quality of stewardship of the National Forest resources must be improved. People both in and out of the Forest Service believe that some important decisions are being made without adequate data about either forest resources or the demands of society. They believe administrative planning has not adequately considered the many consequences of management actions upon the land or the resources. Finally, they are dismayed by the discrepancies between planned, announced actions, and the results actually obtained on the ground.

The public must be assured that future land management decisions will be more firmly based on knowledge that allows reasonable prediction of the outcome of management actions. The Forests must also demonstrate a more unified approach to their common problems, and find more effective ways of actively involving the American people in management planning.

Making and Applying Management Decisions

By Federal law and Department of Agriculture regulations, the Forest Service must manage the National Forests in accordance with the principles of multiple use and sustained yield. The Service is responsible for maintaining long-term productivity of Forest resources and achieving proper balance between social and economic needs in the use and protection of those resources. How the Forests meet their responsibilities depends on the soundness of their management decisions and the skill with which these decisions are applied on the land.

The Planning Process

For quality Forest stewardship, there must be, first of all, good planning, which requires adequate information, well-qualified personnel, and strong administrative support for the planning effort. Within the framework of the Multiple Use Management Guides provided by the Regional Foresters, planning on each of the Forests has progressed considerably over the past decade. Multiple use plans for National Forest System lands are and must be dynamic; each change results in more comprehensive consideration of the capacity of all resources to serve the needs of the people. The rate of progress varies, however, and none of the Forests has attained the required level of planning refinement.

This report has emphasized the role of planning inadequacies in the management errors we observed. Too frequently we found that management objectives were not clearly understood or defined. The decision to build a new road into a previously unroaded drainage, for example, was likely to be based on the use and protection of timber, without adequate consideration of other values. Opportunities were sought to "get the land under management," but action was often started before the Forest or District Staff had defined what they were going to manage for.

The goal of better balance in resource management is attainable, but it will require more effective participation of specialists in soils, hydrology, wildlife, landscape design, silviculture, engineering, and outdoor recreation. To achieve the high-quality management expected by the public, all the Forests must refine, revise, and update existing multiple use plans using an interdisciplinary approach. Plans must be based on adequate sociological, economic, and resource data, and to this end, planners should increase their efforts to seek the counsel of other agencies and interested lay groups.

The Use of Available Information

Good planning requires adequate information. Some of this information is yet to be discovered through research, but much of it can be gathered from available sources.

RESOURCE INVENTORIES

Resource inventories were lacking on all four Forests when extensive logging was begun. At that time, the best information was the Timber Resource Inventory, but because equivalent data were not available about other resources, the Timber Resource Inventory was easily misinterpreted. Although it provided the factual base for calculating the allowable cut, in the absence of data about other important values the calculations did not fully take into account the needs of wildlife and fisheries, recreation, and scenic quality.

The necessary inventory information is now being accumulated, and the Forests, particularly the Teton and Bridger, are making good use of the data in the refinement of multiple use plans. Nevertheless, comprehensive inventories of the basic resources are still lacking. Urgently needed are surveys of soil stability, land suitability, landscape characteristics, hydrological characteristics of watersheds, and the ecological potential and limitations of the forest lands. Areas of special interest should be more thoroughly surveyed and inventoried. These include archeologic and historic sites, areas of importance to rare and endangered species, unique plant communities, unusual landforms or geologic formations, special scenic areas, and key wildlife areas. With this information the Forests could plan their programs for timber and other resources to minimize or avoid conflicts.

SCIENTIFIC AND TECHNICAL INFORMATION

The land manager seldom has all the scientific information he needs and wants, but we encountered several instances where existing helpful information was not used. It has long been known, for example, that the source of seed and timing of seed fall is extremely important in the regeneration of a forest stand. This fact has a critical bearing upon the harvest method, the size of clearcuts, and the method of slash disposal. Cone surveys will supply the needed information for lodgepole pine, but on all four Forests our questions about the seed source and seed potential on sale areas where cuttings were recent, current, or planned, could not be answered. No cone surveys had been made. The lack of adequate natural regeneration on many clearcuts, especially the large ones, reflects the failure to use this source of information to improve the probability of success.

Road construction provides another example. Specific criteria for locating and constructing temporary forest roads in the Rocky Mountain area to minimize soil erosion and prevent sedimentation of streams have been available for the past 10 to 15 years. On all four Forests, however, we observed some temporary roads that were improperly located and constructed, indicating a failure to use the available criteria and guides.

Where knowledge is available but is not being used, the problem is often one of communication. The often-heard claims that research scientists fail to disseminate their findings properly and management specialists fail to search out and apply published research results are still valid; though recognized for years, the information gap has not been closed.

The abilities of technical specialists in the Regional Offices are not fully used, and specialists are often lacking on the individual Forests. On each of the Forests, some poor management decisions might have been improved had the available information and guidance been used effectively. For example, we saw many logging roads built through unstable areas — errors that would probably have been avoided if the assistance of geologists, pedologists, and hydrologists had been used. Although regional specialists are available for consultation and advice, the Forests themselves are shorthanded in such important disciplines as wildlife, soils and hydrology, and landscape architecture.

Until more specialists are available, interim measures are possible. The "literature search" technique is helpful for compiling information on any and all phases of forest management. Professional foresters and land managers have not used this method adequately in Wyoming. At the same time, researchers should not feel that their job is done until they help the practicing forester apply new information on the ground. If the land manager and the researcher communicate as they should, preventable management errors can be significantly reduced.

RECORDS AND ADMINISTRATIVE STUDIES

Useful information is often buried because provision for administrative studies and record keeping is inadequate. Administrative studies should be a continuing part of management programs, as a means of evaluating past and current practices and adapting research findings to specific problems. Yet, at the Ranger District level, work schedules and planning seemed pointed toward present production and future accomplishment. Except for checks on regeneration, we saw little evidence that land management actions had been critically examined to determine causes for success or failure. Similarly, records of management actions are essential to the evaluation of results, but we found Forest personnel were often unsure of the past history of cuttings, road construction, and other management actions. It is understandable that those recently arrived on the scene could not have personal knowledge of such actions, but we did expect to find good records in the District files. Large-scale logging is relatively recent in Wyoming, but already there are some timber sale areas for which no records of sales volume, area cut, and residue treatment are available.

The Search for New Knowledge

Forest personnel readily agree that many past management decisions were made in the absence of much necessary information. This report has emphasized the need for further re-

search in many areas, including resource capabilities. The research effort presently directed to solving these problems is not adequately financed. Support to the Forest and Range Experiment Stations must be substantially increased if the Forests are to receive the kind of assistance they require.

The Forests need more information, for example, on how to regenerate lodgepole pine throughout its altitudinal range and in a variety of habitat types. Similarly, regeneration of Engelmann spruce could be better understood. Without adequate and prompt regeneration of cutover areas, the entire concept of sustained yield is negated and any forest management program is doomed to failure.

The consequences of alternative management actions can only be predicted successfully from knowledge of the ecological relationships among tree species and of the potential of the site to produce vegetation of specific kinds and in specific amounts. Not enough research has been done to classify and define the habitat types common to the Wyoming forests. The land manager needs such tools to make sound decisions.

The Forests of northwestern Wyoming are nationally and even internationally famous for their recreational resources. A large service and supply industry has developed to accommodate the thousands of visitors from many parts of the world. Yet little information is available about what people want to do or see. Research studies are urgently needed to pinpoint the source of visitors, their contribution to the local economy, and their activity patterns. The changing desires and needs of the public should be examined, so that trends may be identified and future needs predicted.

Of all the forest resources, wildlife, the public contends, is least appreciated by the Forest Service. The need for additional information about the effects of logging and roads on elk populations and behavior has been discussed. Two studies, recently started, one in Montana and one in Oregon, may supply some of the needed information. But if the Forests are to provide the kind of positive recognition for wildlife we have recommended, they need something more than solutions to problems of big game management. The recreation experience in Wyoming includes chipmunks as well as moose, and chickadees as well as eagles. Until research provides appropriate information, the Forests can only guess which species are important to the public and how best to recognize that importance.

These comments suggest only a few of the possible lines of research in Wyoming. Others are mentioned in the text and recommendations, but many more could be added in a comprehensive survey of research needs.

For a revitalized forest management program, all available sources of knowledge must be fully used. These environmentally rich forest lands embody resources with potential for timber production and many other uses. But the information for determining priority of uses, or how to manage for the best mix of uses, is only partially known. Universities and the Wyoming Game and Fish Department should be actively encouraged to participate in research efforts coordinated with on-going forest management activities. These studies would provide guidance and new information for the improvement of management practices.

Staffing and Financing

Quality multiple use management takes time, information, and money. None of the Forest employees we interviewed believe that the total job they are asked to do is properly financed. Staffing is inadequate for the task of present administration and protection, still less for the additional effort needed for complex planning. Employees believe workload calculations for timber sale preparation and administration are unrealistic. As a result, the manpower available for timber sale planning is too limited to allow time for thorough study of the silvicultural conditions; once the sale is made, there is not enough time to administer the sale contracts properly. For example, on one District on the Bighorn, a man was administering a going sale, harvesting operations on another sale assigned to him were scheduled to start in a month, and he was preplanning two other sales. Such inadequate staffing does little to insure either quality planning or quality administration.

We share the concern of Forest personnel as to inadequacies and imbalance in manpower

and money to do a quality land management job. The timber management function is now best financed, but it is still not fully adequate. In other resource areas, there are obvious shortages. We can find no fault with the premise that the economic needs of people in Wyoming and elsewhere should be served through judicious use of the timber resource of the National Forests. Historically, these lands were set aside for that purpose. We believe, however, that industrial harvest cutting should not be undertaken unless the funds and manpower are available to accomplish a complete, professional job. We also believe that there must be a better balance in the allocation of funds. Only in this way can the quality of multiple use and environmental protection expected by the public be achieved.

Our observations convinced us that future Forest Service management actions on these National Forests will show much more concern with environmental quality than they have in the past. The changes in management direction have not been in effect long enough, extensively enough, or uniformly enough, however, to convince the public that important improvements are already taking place. An expression of this changing direction toward a better-balanced quality management program appears in a recent statement of the Chief of the Forest Service. Here he emphasizes the intent of the Forest Service to obtain better balance of natural resource uses, to recognize environmental needs more adequately, and to involve the public in management decisions. In essence, "we will go as far as we can in meeting quantity goals, but what we do must be done on a quality basis."[3]

Personnel Tenure and Responsibility

Forest Service personnel and the public are concerned about the frequent transfer of employees in Forest and District positions, and its effect upon sound multiple use management. Transfers are generally made for career development, that is to give the employee wider experience or to promote him to a place of greater responsibility. We were told, however, that tenure in a particular position is sometimes so short that the employee never fully understands the management problems of the District or Forest, and does not come to know the people of the area. The claim was also made that the employee's responsibility is lessened because the person who makes a poor decision may be long gone before the consequences of his actions become obvious. Finally, we encountered a belief that promotional transfers have been based on ability to "get out the cut."

Short tenure, we must agree, is unlikely to lead to the kind of land stewardship that is sensitive to the intangible values represented by a bear or elk wallow or an inspiring view of an unscarred hillside. Without pretending to expertise in personnel management, we believe ways can be found to avoid most of the disadvantages of the policy without sacrificing its benefits. Transfers should be planned somewhat more critically than at present. Although the career development of the employee is important, so too are the needs of the land itself. Promotional transfers could be more clearly based on good stewardship than they appear to be at present.

The matter of responsibility or accountability is somewhat more difficult to evaluate and to correct. Management decisions or actions are rarely individual responsibilities; no one man alone develops a previously unroaded drainage or sets standards and criteria for road construction or timber harvesting. The management mistakes described in earlier pages of this report were not made in a day or year. Some occurred as long as 17 years ago and still have not been corrected. The questions arise: Why were so many of these mistakes in land management allowed to persist? Why was there no better recognition of the conflict they represent with the ethics of the profession? What happened to the inspection system of the Forest Service?

Surely, foresters in their on-the-ground reviews and the regular and periodic inspections from Regional and Washington offices should have picked up these mistakes long before the public outcry began. The fact is, they did not. Who, then, is accountable? The universities

---

[3] *"The Forest Service in the Seventies" by Edward P. Cliff, October, 1970.*

that train and educate foresters and land managers? The professional man on the ground following established guidelines too rigidly or, perhaps, not following them at all? The authors of the guidelines? The inspectors, for not identifying the mistakes earlier? Or all of them? These are not questions for which we have specific answers, but we believe that the internal inspection system used by the Forest Service can be constructively modified to prevent future land management errors.

Stewardship carries with it the responsibility for correcting mistakes as well as avoiding them. On the Wyoming Forests a start has been made toward this goal, but Forest Service credibility will not be re-established until the effects of past management errors have been adequately dealt with. Certain areas have drawn repeated criticism from the public; some examples are Sheridan Creek (fig. 1), Jim Creek (fig. 2), East Fork of the Tongue River (fig. 7), and Jules Bowl (fig. 8). A clearly evident effort to clean up the untreated slash, smooth out the bulldozer tracks, and stabilize loose soils with vegetation and trees will do more to demonstrate quality stewardship than the mere admission of past mistakes. In some areas, a concentrated "gardening" effort may be required. We believe this effort should be assigned a very high priority at both Forest and Regional levels.

RECOMMENDATIONS

- **The Regions and Forests must better define resource management and environmental protection goals for the Forests and refine and update multiple use plans to include decisions that meet these goals.**
- **Resource inventories should be completed for all major resources.**
- **The Forests and Regions should strive toward a balance of resource skills in the Forest staff.**
- **More effective use should be made of existing information by (a) the forester, who should search the literature for usable ideas, and (b) the researcher, who should work more closely with the forester in putting new methods into practice.**
- **Periodic evaluation of the results of management activities should be an integral part of the land management job.**
- **The Forest Service should strengthen the current research effort in Wyoming and should explore ways of using abilities outside the Service to develop needed information without delay.**
- **No industrial harvest should be undertaken unless adequate funds and manpower are available to do a complete, professional job.**
- **Tenure and transfer policies should assure that quality land management is not itself sacrificed to provide land managers with the training and experience they need to achieve quality management.**
- **Forest Service internal inspection procedures should be reviewed to determine why questionable practices were not detected before they provoked public criticism.**
- **The Forests and Regions should evaluate timber harvest areas that have drawn repeated public criticism and begin major rehabilitation programs where necessary to improve the visual image and protect other resource values.**

Correlating Management Policies

A variety of management actions on the four Forests have been criticized by the public as representing policies that are inconsistent from one Region or Forest to another. Differences have been most noticeable in the slash disposal techniques on the Shoshone and Teton Forests, discussed under "Logging Residue." Similar differences, however, can be observed in silvicultural methods, standards of road construction, and attitudes toward public participation in Forest management. In some instances, these differences have led the public to believe that established plans were being violated. For example, the Teton Forest Supervisor has announced that clearcuts will be no larger than 40 acres. The Bighorn Forest has a

similar policy, but continues to cut from 100 to 300 acres in single blocks as required by existing sale contracts.

We believe the public has the right to expect an underlying consistency in the policy decisions and land management practices of the Forest Service. This does not mean, however, that uniformity is either feasible or desirable. To recommend tighter control from the Washington Office through the Regions and Supervisors right down to the Ranger District would, we believe, only compound the problem. Some of the land management errors already described can be traced to overly specific guidelines that did not allow flexibility in decision-making as required by varying conditions on the ground. Every land management action proposed for a specific land unit requires an individual prescription prepared in conformity with the multiple use plan. Where planning is incomplete and key values unspecified, management actions are bound to be inconsistent.

The need for greater flexibility is evident also in the area of timber sale contracts. Generally, a contract is in force for 3 or 4 years from the time the planning is completed and the contract is prepared. During this period new standards of performance may become established, new information on what should be done to protect or enhance resource values may become known, or inadvertent errors in the planning may become evident. Any or all of these situations might require modification of the contract to correct these deficiencies.

Several foresters we talked to were concerned that the contract was not sufficiently flexible to permit such changes and that operations on the ground were, therefore, not always of a quality fully compatible with multiple use management objectives. Some typical situations involving conflict between timber values and other resource values were described. For example, a clearcut unit in an existing timber sale contract may be larger than is currently considered desirable. Or, it may be found that in logging out a clearcut, the upper edge of the cutting unit will be visible from a main highway, with poor effect. To correct this situation, the purchaser may suggest moving the unit boundary 100 feet downhill, thus protecting the scenic visual corridor related to the road, provided that he can obtain compensating volume on another side of the unit.

Although minor changes in cutting unit boundaries are permissible, any modification of contract must be held within limits that reflect the intention of the original conditions of the sale. This may prevent making desirable changes and the resource suffers. In the second example, the change can be made only if the value of the timber included in any additions to compensate for excluded areas is less than $2,000.[4]

An example of hardship to the timber purchaser was also described. When the volume of timber harvested from a sale is less than the advertised estimate, the timber purchaser is unable to fully amortize his investment in the sale. A substantial reduction in volume can result in rather severe economic strain. Adjustment of the sale boundary by the forest officer to bring the cut volume up to advertised estimate is a violation of Federal regulations and the purchaser suffers.

The problems of contract modification are complex. Timber purchasers have worked with the Forest Service for many years to design a timber sale contract that is not subject to arbitrary change at the local level. This is reasonable. The wood industry, in general, is a high-risk business, and the purchaser needs to know that his expenses will be essentially as predicted at the beginning of the sale. On the other hand, Department of Agriculture regulations require that modification of a contract must be "to the advantage and benefit of the United States."[5] Again, this is reasonable. Benefit, however, is often interpreted in terms of deposits in the U. S. Treasury. When contracts cannot be modified to consider benefits not measured in dollars, good resource management becomes more difficult.

In general, the interpretation of laws and regulations that determine timber sale contract policy is outside the control of the Forest Service. We believe, however, that provision should be made for contracts that will benefit the Government, satisfy the purchaser, and above all,

---

[4] *Forest Service Manual, 2433.23*

[5] *Title 36, Code of Federal Regulations, 221.16*

protect the resource. The Forest Service should explore this problem further and work toward solving it by obtaining statutory authority to make appropriate contract modifications.

RECOMMENDATIONS

- **The Regions and Forests should strive for an underlying consistency in policy through good planning, but should preserve the flexibility needed to insure that management practices are appropriate to site conditions.**
- **The Forest Service should seek statutory authority to modify contracts to protect environmental values.**

Involving People

The American people, as represented by those we talked to, have made it emphatically clear that they are concerned with the management of their National Forests. We believe the Forest Service is obligated to involve the public in every possible way, but particularly by more effectively seeking public opinion in the early stages of planning, long before management actions take place on the ground.

Past actions by the Forest Service have been judged by some critics to demonstrate an inability to grasp and respond to public opinion. This is not a fair judgment. The demand for greater public involvement is relatively recent and the Forest Service is, in fact, responding to criticism. It is true that the response has not kept pace with public demands, but forest management is a long-term obligation, and there is danger in too-rapid shifting with the winds of public opinion.

For the future, the Forest Service must find more reliable methods of predicting public wishes and public needs. These methods must assure that all segments of the public have the opportunity to be heard, and that their counsel is considered in management planning. It seems clear that public involvement will not be achieved simply by information and education programs. A completed plan in which the public has had no part places the Forest Service in a defensive position. On the other hand, the public cannot contribute constructively to the planning process unless they are provided with factual information upon which to make judgment and consider options.

Thus, the foundation for public involvement is the basic resource inventory we have called for as an essential element in management planning. With this information in hand, the Forests can consult with people in identifying management alternatives and can discuss the benefits and consequences of different management goals. The plans thus developed will reflect public demands as well as the technical and ecological realities that determine how and to what extent these demands can be met. Both the Forests and the public should recognize the need for continuing review and maintenance of flexibility in planning; and both should recognize that no amount of input by the public and no amount of planning can entirely eliminate conflict in multiple use management. Every decision is subject to criticism by some segment of the public. The very best the Forest Service can achieve is a reasonable balance of all the viewpoints presented.

RECOMMENDATION

- **The Forests should make every effort to involve the public in the planning process by (a) identifying appropriate land management alternatives through listening to people and giving them forest resource information, and, (b) assessing public opinion as to choice of alternatives.**

SUMMARY OF RECOMMENDATIONS

This report of our investigation of management on the four Forests has recognized that changes are needed. Errors have been made; they should be corrected wherever possible and they should not be repeated. We have emphasized, however, that the need to preserve and enhance environmental quality is recognized in multiple use planning, a Forest Service policy that has been in effect for many years. The problem has been to translate policy into practice by changing traditional attitudes toward the dominant place of timber harvest in forest values. Change is always slow, but in forest management it must be speeded up if further errors and possible damage to the resource are to be prevented.

Overreaction to the criticism that prompted this investigation must be avoided, however. Ill-considered decisions made to satisfy public demands will do harm rather than good. A reasonable course of action will concern itself with long-term progress in protection and improvement of environmental quality, concurrent with appropriate commodity utilization.

The following recommendations are taken from the text of the report. They should be considered in the light of the discussion of specific topics indicated in the headings.

BASIC RECOMMENDATIONS

- The importance of wildlife, recreation, and scenic quality as key values should be recognized in every management decision on the National Forests of Wyoming.
- Multiple use planning should be a team effort, using input from Forest Service specialists in all appropriate areas of knowledge, and from interested citizens and organizations as well. Therefore:
  - Plans reflecting these inputs should be clearly stated and announced to the public in an understandable form.
  - Agreed-upon plans should be fully implemented in a manner clearly evident to the public.
  - The effectiveness of planning should be periodically evaluated and the results reported to the public.
- Needs for adequate staffing for the development, implementation, and evaluation of plans should be explicitly stated in Forest Service budget requests.
- Every member of the Forest Service should be committed to the principles of high-quality multiple use management and to the urgent necessity for putting these principles into practice.

CLEARCUTTING

The Place of Clearcutting in Wyoming Silviculture

- Timber sale plans should include silvicultural prescriptions by qualified silviculturists and specific instructions for timber harvest; long-term evaluation of the effects of the prescription should be mandatory.
- In lodgepole pine
  - The Forests should continue to use clearcutting where it is a sound silvicultural harvesting method and in harmony with management objectives for the unit of land.
  - Alternatives to clearcutting, such as seed-tree and shelterwood cutting and overstory removal, should be used where such methods are consistent with the ecological requirements and protection of the species or appropriate to other uses of the forest land.
  - Thinning and sanitation salvage should be used independently or in combination with clearcutting where economically feasible.
- The present limitation on clearcutting in the Englemann spruce—subalpine fir type should be continued until satisfactory regeneration practices have been developed.
- The Forests should consider using a light selection cutting or "pussyfoot logging" on low-yield sites.

- The Experiment Stations should vigorously carry out research to classify and define plant habitats and their ecological potential for both lodgepole pine and Engelmann spruce—subalpine fir forest types in Wyoming.
- Forest Service Research and Administration should speed up action to develop systems for analyzing the true costs and benefits of forest management alternatives.

Modifying Clearcutting Methods to Protect the Environment

- Clearcut size limits must be determined by the resource values to be considered and by the specific characteristics of the harvest area.
- More and better use should be made of the knowledge that specialists in soils, hydrology, and related areas can furnish in planning timber management operations.
- Timber sale contract requirements providing for protection of live stream channels from unnecessary disturbance and from clogging with logging residue should be strongly enforced.
- Research should determine (a) the kinds and sizes of areas and proportions of watersheds that can be safely clearcut at one time without creating damaging changes in streamflow quantity, quality, or timing; and (b) the nature and magnitude of changes in onsite nutrient content and of eutrophication of streams that may result from soil and vegetation disturbances that attend timber harvesting.
- Until more specific information becomes available, clearcuts in big-game habitats should be limited to 40 acres and should be no closer than 200 feet to existing openings.
- Research and monitoring of wildlife behavior as affected by timber harvest should be encouraged in Federal and State agencies.
- Unless wildlife budgets can be substantially increased, the costs of evaluating effects of timber harvest on wildlife should be properly considered a part of the timber harvest obligation.
- Multiple use planning should give particular attention to the long-term effects of timber harvest in limiting the options for future recreational use of land.
- The Regions should encourage research that will help the Forests to achieve comprehensive recreation management appropriate to the desires of people and the potential of the land.
- The basic character of Wyoming wildlands should be kept dominant, and manmade alterations held subordinate, in design of clearcuttings. To do this:
  - The design of cuttings, including size, shape, location, and dispersion, should respond directly and specifically to visual characteristics of the landscape.
  - Scenic inventories, recording at least dominant landscape resources, should be made to aid in planning and design.
  - Forest personnel should be given training to develop greater managerial sensitivity to landscape resource values.

ROADS

Road Planning and Maintenance

- Transportation plans should indicate the purpose of every proposed road — whether permanent or temporary, the disposition of each temporary road, and the maximum level of road construction needed to attain management objectives.
- The transportation plan should be clear and logical, and presented in a form easily understandable to the public, and should specify drainages that will be exempt from any road construction or managed with temporary roads only.
- The temporary roads still open should be carefully evaluated; those classified as temporary should be closed and all others reconstructed as required for maintenance as part of the permanent road system.

- In road layout and design, the relation between the road and the landscape should be clearly established so as to avoid a result suggesting single use.

Controlling Environmental Effects of Roads

- The quality of design, location, and construction of roads, especially temporary ones, must be greatly improved to avoid unnecessary damage to soil and water.
- Existing specifications that temporary roads should be maintained for adequate drainage before winter should be scrupulously observed.
- Much greater use should be made of geologists, hydrologists, and soil scientists in planning and constructing roads.
- The Forests and Regions should actively encourage cooperative research to determine the impact of road systems on elk populations.
- The Forest Service should carefully consider a slowdown in construction of new permanent roads until information is available concerning the effects of roads on elk.
- Road location and design should be better coordinated with the landscape than they are at present:
  - Planning and road design should routinely include thorough exploration of visual alternatives.
  - The visual corridors created by both existing and proposed highways and permanent forest roads should be recognized as requiring special attention.
  - More flexible road design standards, encouraging small scale roads where they are appropriate, should be adopted.

LOGGING RESIDUE

- Forest Service Research, National Forest Administration, and the timber industry should jointly explore possibilities for using more of the wood left after logging, and for treating the remaining residue to facilitate natural and artificial regeneration and reduce the unfavorable visual impact.
- The Forest Service should establish exploratory studies to determine the effects of logging residue management on water quality.
- The Forests should secure timely meteorological information, and require that logging residues be burned during periods when burning is least likely to affect air quality adversely.
- The Forests should do a complete job of treating right-of-way clearing residues concurrent with construction of all roads open to public travel.
- The Forests should eliminate the backlog of untreated residue as soon as possible.

REGENERATION

- The silvicultural prescription for each stand should include surveys to determine degree of serotiny in the stand, and monitoring to forecast occurrence of seed crops and to estimate seed production.
- A regeneration check list should be developed for each proposed timber sale, outlining (a) the sequence of events affecting regeneration, and (b) the treatments needed to obtain satisfactory regeneration, including backup treatments to compensate for failure of any one step.

FOREST STEWARDSHIP

Making and Applying Management Decisions

- The Regions and Forests must better define resource management and environmental protection goals for the Forests and refine and update multiple use plans to include decisions that meet these goals.
- Resource inventories should be completed for all major resources.

- The Forests and Regions should strive toward a balance of resource skills in the Forest staff.
- More effective use should be made of existing information by (a) the forester, who should search the literature for usable ideas, and (b) the researcher, who should work more closely with the forester in putting new methods into practice.
- Periodic evaluation of the results of management activities should be an integral part of the land management job.
- The Forest Service should strengthen the current research effort in Wyoming and should explore ways of using abilities outside the Service to develop needed information without delay.
- No industrial harvest should be undertaken unless adequate funds and manpower are available to do a complete, professional job.
- Tenure and transfer policies should assure that quality land management is not itself sacrificed to provide land managers with the training and experience they need to achieve quality management.
- Forest Service internal inspection procedures should be reviewed to determine why questionable practices were not detected before they provoked public criticism.
- The Forests and Regions should evaluate timber harvest areas that have drawn repeated public criticism and begin major rehabilitation programs where necessary to improve the visual image and protect other resource values.

Unifying Management Policies

- The Regions and Forests should strive for an underlying consistency in policy through good planning, but should preserve the flexibility needed to insure that management practices are appropriate to site conditions.
- The Forest Service should seek statutory authority to modify contracts to protect enviromental values.

Involving People

- The Forests should make every effort to involve the public in the planning process by (a) identifying appropriate land management alternatives through listening to people and giving them forest resource information, and, (b) assessing public opinion as to choice of alternatives.

LITERATURE CITED

Alexander, Robert R.
1958. Silvical characteristics of Engelmann spruce. U. S. Dep. Agr., Forest Serv., Rocky Mountain Forest & Range Exp. Sta., Sta. Paper 31. Fort Collins, Colo. 20 p., illus.

Bartsch, A. F.
1959. Settleable soils, turbidity, and light penetration as factors affecting water quality. Seminar on Biological Problems in Water Pollution Trans. 1959. U. S. Dep. Health, Education & Welfare. Tech. W60-3, p. 118-127.

Beaufait, William R.
1968. Scheduling prescribed fires to alter smoke production and dispersion. In: Prescribed burning and management of air quality. Southwest Interagency Fire Council (Tucson, Ariz., Nov.) Proc. 1968: 33-42.

Crossley, D. I.
1956. Effect of crown cover and slash density on the release of seed from slash-borne lodgepole pine cones. Can. Dep. Northern Affairs and Natural Resources., Tech. Note 41, 51 p., illus.

Goodell, B. C.
1958. A preliminary report on the first year's effects of timber harvesting on water yield from a Colorado watershed. U. S. Forest Serv., Rocky Mountain Forest & Range Exp. Sta., Paper 36. 12 p.

Hibbert, A. R.
1967. Forest treatment effects on water yield. Proc. Int. Symp. on Forest Hydrology held at Pennsylvania State Univ., Aug. 29-Sept. 10, 1965: 527-543. Pergamon Press.

Likens, Gene F., F. Herbert Bormann, Noye M. Johnson, D. W. Fisher, and Robert S. Pierce.
1970. Effects of forest cutting and herbicide treatment on nutrient budgets in the Hubbard Brook watershed-ecosystem. Ecol. Monogr. 40(1): 23-47.

Litton, R. Burton, Jr.
1968. Forest landscape description and inventories — a basis of land planning and design. USDA Forest Serv. Res. Pap. PSW-49, Pacific SW. Forest & Range Exp. Sta., Berkeley, Calif. 64 p., illus.

Lotan, J. E.
1963. Sampling serotinous cones in lodgepole pine. Mont. Acad. of Sci. Proc. 23: 22-24.

Love, L. D.
1955. The effect of streamflow on the killing of spruce and pine by the Engelmann spruce beetle. Amer. Geophys. Union Trans. 36, p. 113-118.

Murie, Olaus J.
1951. The elk of North America. Washington, D. C.: Wildlife Manage. Inst. 376 p.

National Academy of Sciences
1970. Land use and wildlife resources. Comm. on Agr. Land Use and Wildlife Resources, Div. Biology and Agr. Nat. Res. Council. National Acad. Sci., Washington, D. C. 262 p.

Northwest Region of Federal Water Pollution Control Administration
1970. Industrial waste guide in logging practices. U. S. Dep. Interior, Portland, Ore. 77 p., illus.

Packer, P. E.
1967. Forest treatment effects on water quality. Proc. Int. Symp. on Forest Hydrology held at Pennsylvania State Univ., Aug. 29-Sept. 10, 1965: 687-699. Pergamon Press.

Reynolds, H. G.
1962. Effect of logging on understory vegetation and deer use in a ponderosa pine forest of Arizona. U. S. Dep. Agr., Forest Serv., Rocky Mountain Forest & Range Exp. Sta., Res. Note 80. 7 p.

Reynolds, H. G.
1966a. Use of openings in spruce-fir forests of Arizona by elk, deer, and cattle. USDA Forest Serv., Rocky Mountain Forest & Range Exp. Sta., Res. Note RM-66. 4 p.

Reynolds, H. G.
1966b. Slash cleanup in a ponderosa pine forest affects use by deer and cattle. USDA Forest Serv., Rocky Mountain Forest & Range Exp. Sta., Res. Note RM-64. 3 p.

Roe, Arthur L., Robert R. Alexander, and Milton D. Andrews
1970. Engelmann spruce regeneration practices in the Rocky Mountains. USDA Forest Serv., Prod. Res. Rep. 115. 32 p., illus.

Ronco, Frank
1970. Influence of high light intensity on survival of planted Engelmann spruce. Forest Sci. 16: 331-339.

Schneider, Phillip W.
1970. People's needs and expectations for fish and wildlife. Comments to Western Forestry and Conserv. Ass., 61st Western Forestry Conf., Vancouver, B. C. 11 p.

Shaw, P. A., and J. A. Maga
1943. The effects of mining silt on yield of fry from salmon spawning beds. Calif. Fish & Game 29: 29-41.

Stevens, David R.
1966. Range relationships of elk and livestock, Crow Creek drainage, Montana. J. Wildlife Manage. 30(2): 349-363.

Wallmo, O. C.
1969. Response of deer to alternate strip clearcutting of lodgepole pine and spruce-fir timber in Colorado. USDA Forest Serv., Rocky Mountain Forest & Range Exp. Sta., Res. Note RM-141. 4 p.

AFLC/HAFB, Ogden

WOOD · WATER · FORAGE · WILDLIFE · RECREATION
FOREST SERVICE
US
DEPARTMENT OF AGRICULTURE